CONSTRUCTION MATERIAL LOGISTICS MANAGEMENT: THE CASE OF NORTH-CENTRAL NIGERIA

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CONSTRUCTION MATERIAL LOGISTICS MANAGEMENT: THE CASE OF NORTH-CENTRAL NIGERIA

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by

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Declaration

I, Polycarp Olaku ALUMBUGU with student number 216788099 hereby declare that the thesis for the award of the degree of Doctor of Philosophy in Construction Management is original work and that it has not previously been submitted for assessment or completion of any postgraduate qualification at another University or institute of learning.

Signed: …….

Date: November 12, 2019

Abstract

The Management of Construction Material Logistics Systems plays a significant role in meeting the goals of cost, quality and time to completion of a construction project. Studies have revealed that the cost of construction material is usually about 50%-60% of the total cost of a project, and that the logistics cost accounts for between 17%-35% of the cost of that material. Fundamentally, it is accepted that any inefficiency in the delivery of construction material could lead to a time overrun and thus, a rise in construction costs. Therefore, addressing the operational performance of logistics would have a positive impact on the goals of a construction project. The aim of this study was to investigate and evaluate the operational performance of material logistics in North-Central Nigeria as there is little specific research conducted on its effectiveness and efficiency. The methodology used included an extensive literature review and a field study conducted on ten selected construction manufacturing firms. A quantitative approach that is rooted in the positivist paradigm, and purposive sampling techniques, was adopted. A research instrument was developed and used in conjunction with an observation protocol in the form of a template. The descriptive method of data analysis was employed, and the findings and interpretations presented through graphs and images. Analysis of the findings led to the conclusion that material logistics did not operate as a system. There was almost no collaboration and integration of the logistics systems to create a synergistic interrelationship between functions in pursuit of higher overall effectiveness and efficiency. Improvement was needed in warehouse and transport operations and processes; technology and automation of logistics operations were absent, and delivery of material to customers was not effective. The implication was that the current materials logistics system did not meet the delivery goals of cost, quality and time of a construction project. The recommendations suggested included the adoption of the framework developed in this study. This would serve as a guide towards effective and efficient logistics management for material manufacturing firms, and for construction professionals.

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Dedication

This research study is dedicated to my God Almighty, my Creator. His faithfulness to me gave me support, provision, protection and guidance.

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Abbreviations used in this Study

ABC	Always Better Control
AGVS	Automated Guided Vehicle System
AITS	Automated Inventory Tracking system
AMR	Autonomous Mobile Robots
AS/RS	Automatic Storage and Retrieval System
ATC	Authority To Collect
Auto-ID	Automatic Identification Technology
BIM	Building Information Modelling
BM	Builders Merchants
CDC	Central Distribution Centre
CILT	Chartered Institute of Logistics and Transport
CIM	Centralised Inventory Management
CPA	Construction Products Association
CPFR	Collaborative Planning, Forecasting and Replenishment
CRP	Continuous Replenishment Policy
CSCM	Construction Supply Chain Management
CSCMP	Council for Supply Chain Management Professionals
DC	Distribution Centres
DfT	Department for Transport
DRP	Distribution Requirement Planning
DT	Dwell Time
ECR	Efficient Consumer Response
EDI	Electronic Data Interchange
EFT	Electronic Fund Transfer
EIS	Enterprise Information Systems
ERP	Enterprise Resource Planning
FCT	Federal Capital Territory, Abuja
FMCG	Fast Moving Consumer Goods
FTL	Full Truck Loads
GIS	Geographical Information System
GPRS	General Packet Radio System
GPS	Geographical Positioning System
IDS	Information Directed System
IMO	Inventory Management Optimisation
IT	Information Technology
ITS(a)	Integrated Transport System
ITS(b)	Intelligent Transportation System
JIT	Just-In-Time
LDC	Local Distribution Centre
LTL	Less than full Truck Load
MCP	Mass-Customerised Production

MFC	Manufacturing Company
MHE	Material Handling Equipment
MHI	Material Handling Institute
MRP	Material Requirement Planning
MRPII	Manufacturing Resources Planning II
MS	Material Suppliers
MTA	Metric Tonnes Per Annum
₦	Naira (Nigeria monetary unit)
NBS	National Bureau of Statistics
QR	Quick Response
RFID	Radio Frequency Identification
RR	Rapid Replenishment
SCM	Supply Chain Management
SCR	Synchronised Consumer Response
SFC	Strategic Forum for Construction
SKU	Store Keeping Unit
TAC	Total Acquisition Cost
TL	Truck Load
TMS	Transport Management Systems
TQC	Total Quality Control
TQM	Total Quality Management
VB	Vanadium Boride
VJE	Vehicle Journey Efficiency
VLE	Vehicle Loading Efficiency
VMI	Vendor Managed Inventory
VRP	Vehicle Route Problem
VSAT	Very Small Aperture Terminal
VSE	Vehicle Shipping Efficiency
VUE	Vehicle Utilisation Efficiency
VWE	Vehicle Weighted Efficiency
WERC	Warehouse Education Research Council
WH	Warehouses
WMS	Warehouse Management System
WRAP	Waste and Resources Action Program

Chapter 1: The Research Problem and its Setting

1.1 Introduction

Construction material is a basic constituent in construction projects and can make an important contribution to the cost effectiveness of projects (Kasim, Latiffi and Fathi, 2013:7; Abhilin and Vishak, 2017:911). Research has revealed that the cost of construction material is usually about 50%-60% of the total cost of a project (Kasim, Liwan, Shamsuddin, Zainal and Kamaruddin, 2012:450; Duiyong, Shidong and Mingshan, 2014:353). Apart from the direct cost, the costing of material also includes the cost of logistics. The logistics cost accounts for between 17% - 35% of the cost of material (Duiyong, Shidong and Mingshan, 2014:353). The importance of construction material logistics in the execution of a project cannot be over emphasised because projects are made difficult by material inadequacies, deferrals in supply, increment in cost, material wastage and damage , and the absence of storage space (Kasim, Latiffi and Fathi, 2013:7; Abhilin and Vishak, 2017:911).

Clearly, organising and managing of material is critical as they directly influence the construction plan and cost. For instance, if a problem arose, it would then trigger resultant issues on different parts of the task, which would then bring about delays and cost overrun, as confirmed by Cho, Kwon, Shin, Chin and Kim (2011:14). Additionally, the cost of construction material also constitute a significant danger to both the construction industry and prospective house owners (Mekson, 2008:21). Idoro and Jolaiya (2010:103) confirmed that many projects were not completed on time due to an increase in the cost of materials. The whole execution of a project relies on the logistics of the on-site and outside project collaborators of the logistics system (Ying, Tookey and Roberti, 2014:262). Solving the logistics problem in construction can affect client service levels, in addition to the cost and sustainability of supply chains.

Logistics should also be seen from the wastage point of view. Such wastage includes improper handling of material and several persons handling it as well (Elfving, Ballard, and Talvitie, 2010:292, Voigtmann and Hans-Joachim, 2010: 3201). Another problem is the obstruction of storage areas (Voigtmann and Hans-Joachim, 2010:3202; Said and El-Rayes, 2014:110). The distance between the storage area and work site is an

essential cause of waste because of the movement frequently done by unskilled workers (Said and El-Rayes, 2014:110). Lack of materials when required, inadequate confirmation of materials, re-handling with an absence of enough warehouse/ storerooms are further reasons behind delays, resulting in unnecessary work (Sardroud, 2012:381). These factors all could lead to a loss in production efficiency and an increase in the cost of projects.

When construction problems were reviewed, what came to the fore was that many of them were related to the supply chain process, as well as the interface between the roles of the different participants (Strategic Forum for Construction and Construction Products Association (SFC/CPA), 2005:84). This implies that the logistics of a construction project form an important part of the Construction Supply Chain Management (CSCM). Hence, Anna and Agata (2005:73) and Zhang and Wu (2007:123) advocate for the need to reduce the size, structure and organisation of material consumption. This includes modes of delivery, and better planning for efficient and effective project management.

1.1.1 Global View of Construction Materials Logistics Management

Several studies on construction logistics examined the practices that established the drivers and barriers to efficient approaches (Omar, Hassan and Ballal, 2010:321). When working on a congested project, it was important to decrease the quantity of inventories (Said and El-Rayes, 2014:110). Then Mossman (2008:8), noticed that projects with confined sites required thorough logistics planning for efficient completion.

In Hong Kong, the use of Radio Frequency Identification (RFID) technology has been adopted in several sectors, for instance merchandising stores. This includes computerised transactions, logistics and supply-chain administration, scientific study and security. It has improved immediate information visibility and traceability (Lu, Huang and Li, 2011:101). However, a far-reaching utilisation of RFID technology in construction has not occurred. One conceivable reason is that construction professionals may have not been well informed about its potential (Lu, Huang and Li, 2011:101).

Information Technology (IT) is a known enabler for improving logistics efficiency. However, paper-based reports are still used to record trade data connected to the material supply chain. This is challenging, inclined to error and wasteful (Kasim, Latiffi and Fathi, 2013:7). Furthermore, a study of Warehouse Management Systems (WMS) demonstrated that execution and profitability are diminished when the operations were done by hand. All could be done more effortlessly and adequately if automated (Ramaa, Subramanya and Rangaswamy, 2012:19). Regardless of scientific and technological advancement, the logistics system is still contributing to project delays and cost overrun, thereby leaving unhappy clients in its wake (Morledge, Knight, and Grada, 2009:146).

Transport plays a critical role in logistics. Competition among logistics companies is fierce, as illustrated in Mexico. Exacerbating their context is the severely deficient transport infrastructure (Bernardo, Cortez, Carrales, Novelo and Gonzalea, 2009:101). The problem of transport is valid in the construction industry as well. Shakantu and Emuze (2012:661) observed that much importance is placed on Supply Chain Management (SCM) but deprived of the vital knowledge of its top subsections, such as transportation. For example, construction material and transport providers/ waste removal still operate as independent businesses.

In a competitive world market, the extent of cost, quality, efficiency and customer service level should not be compromised by the manufacturing industry. All stakeholders should be an integrated whole working together to serve the customer. The manufacturing companies have endeavoured to decrease the cost of production and distribution (Jean-François and Lauri, 2014: 4). More can be done if one notes that an effective supply chain performance can reduce delivery time by twenty percent (20%), as confirmed by Errasti, Beach, Oduoza, and Apaolaza (2009:268). This proves that the cost of logistics rises through any inefficient logistics performance.

In the United Kingdom, Khalfan, McDermott, Li, Arif, and Kashyap (2008:358) did a study on partnerships between suppliers and manufacturers. The advantages of innovative procurement systems were a result of this collaboration of outbound logistics systems. The study concluded that there is extraordinary potential to use the know-how and understanding of suppliers and manufacturers at the start of a project

to accomplish effective planning and delivery of the whole project, simply through greater supply chain collaboration (Khalfan, *et al.*, 2008:358).

1.1.2 Construction Material Logistics Management in Nigeria

The unavailability of construction material enormously influences their cost, as confirmed by Equere and Tang (2010:102). In Nigeria, construction materials such as crushed stones, sand, steel, cement, wood, aluminium and glass should be easily obtained locally. However, some of these materials must be imported to compensate for times when they are not available.

According to the Nigerian National Bureau of Statistics (NBS) (2015:47), the total intermediate contribution of some selected local building materials to the construction sector increased by 14% from 2010 to 2011, while it increased by 22% from 2011 to 2012. The enormous contribution of producing building and construction materials locally cannot be over emphasised (Adedeji, Opeyemi, Rapheal and Ijeoma, 2016:15).

In Nigeria, some studies were conducted on the management of construction material logistics. The studies on the logistics system of cement producers revealed that the only mode of transportation being used was by road. The railway system is obsolete and not in good condition (Adebumiti and Muhammed, 2014:234; Adebumiti, Muhammed, Faniran and Masugari, 2014:242). Adebumiti and Muhammed (2014:235) also identified challenges being faced in the distribution of cement in Nigeria. The chemical and paint manufacturers revealed that the customers of these materials were not satisfied with how they were distributed (Obiegue, 2010:8). In addition, Obiegue (2010:8) noted that some of the manufacturers faced problems with poor infrastructure, inadequate inventory management, inefficient warehouses, backward communication facilities, an unprofessional business environment and limited political/ government support. Another study revealed that very little interaction occurred between contractors and suppliers (Saka and Mudi, 2007:777; Oludare and Oluseye, 2015:18). Also, the inefficiencies associated with the practice of manually tracking material, equipment and workers in the construction sector often caused problems, resulting in the delay of timely execution of a construction project (Equere and Tang, 2010:101).

According to Jang and Skibniewski (2009:378), the advancement in technology and innovation in the construction industry should make it, in fact, reasonable to execute an automated monitoring and tracing system for material. Even though the construction industry in Nigeria has advanced to the point of executing big and complex projects, they still largely operate manually. It becomes imperative, therefore, that material handling and tracking be automated to efficiently manage further anticipated growth. Time and effort cannot be wasted through the labour-intensive processes of reporting and documentation, and communication from site through the present manual systems, especially as the construction projects increase in size and scope (Jang and Skibniewski, 2009:378 ; Equere and Tang, 2010:102).

A survey of the utility of Building Information Modelling (BIM) in the Nigerian building industry revealed that the clients, design teams, contractors and suppliers had not heard of BIM before. They did not even know its value to the construction sector (Dim, Ezeabasili and Okoro, 2015:001). Small contractors and material suppliers used telephones to conclude business transactions.

All the above findings exposed the fact that, in Nigeria, there has been little study done on the logistics process and operational performance.

1.1.3 Identification of the Research Gap

In reviewing studies on construction logistics, Seppänen and Peltokorpi (2016:75) observed that reducing the cost of logistics from the contractors' point of view was the most widely recognised perspective. Previous studies into construction logistics management had focused on two key areas. Principally, these areas of study are identified as 'internal'' meaning that the project site has the objective of increasing construction performance through efficient material handling and a realistic delivery plan (Veiseth, Røstad, and Andersen, 2003:191, Elsborg, Bertelsen, and Dam, 2004: 14; Ala-Risku and Kärkkäinen, 2006:19). The second area of study focused on the various tiers in the supply chain to enhance the collaboration between suppliers and clients. The studies by Agapiou, Flanagan, Norman and Notman (1998:356); Wegelius-Lehtonen and Pahkala (1998: 690); Shakantu (2005:44); Vidalakis, Tookey and Sommerville (2011:70) confirmed the second area. Therefore, their focus can be

classified into “Project” and “Supply Chain” logistics management studies (Vidalakis, Tookey and Sommerville, 2011: 70).

Manufacturers of construction materials are external to the organisation of the project and are thus observed to be of lesser significance in the Project Approach. Consequently, the logistical function of manufacturers, even though critical, has been largely ignored. Vidalakis, Tookey and Sommerville (2011:72) suggested the need to expand the scope of logistics management outside the environment of the project. This would become necessary when considering that the shortcomings account for a considerable amount of waste incurred in the construction industry’s supply chains (Egan, 2002:18). This is seen to be a substantial omission in the current Construction Supply Chain Management (CSCM) body of knowledge in the Nigeria. This omission prompted the need for an investigation into the issue of how logistics is managed, specifically from the construction materials manufacturers’ perspective.

1.2 Problem Formulation

Previous research treated the elements of the logistics system separately. These elements include sourcing, production and scheduling, inventory, warehousing and transportation. Many complex supply chain interactions were ignored (Okeudo, 2012:57; Faber, 2015:1). Analysis of construction logistics management has demonstrated that a significant aspect of the supply chain difficulties emanate from interface of various partners (Vidalakis and Tookey, 2006:907). A decision by one organisation in the chain influences the choices of other organisations, thus the logistics system is a more suitable element for investigation as opposed to an individual organisation.

Ramaa, Subramanya and Rangaswamy's (2012:19) study revealed that there are many bottlenecks in the WMS operation. The absence of automation leads to major errors that negatively affect costs and schedule (Grau, Caldas, Haas, Goodrum, and Gong, 2009:912). The performance and efficiency of the warehouse suffered as the operations were done manually, instead of using modern technology more effectively. In addition, manufacturers were found to be lacking in terms of production machines, warehouse space, trucks and even drivers. Such shortcomings could have a major influence on the overall logistics performance (Yang, 2013:1). Jones and Womack

(2002:234) recommended the reduction in level of operations in the supply chain. These included unnecessary stock holdings, transportation and inefficient information flow, all of which make the logistics system ineffective.

Crainic and Laporte (1997:409) identified inefficiency at the operational level of outbound logistics systems. This affected preparation of services, vehicle empty runs, collaboration, planning and sharing of resources. Besides, Shakantu (2005:154) lamented the traffic-jams and pollution on public roads, which has led to studies on how to control the flow of traffic in large cities. While exploring this situation, Tseng, Yue and Taylor, (2005:1658) identified the need for a clear framework of a logistics system that connects the manufacturers logistics system with that of the construction industry. There have been initiatives targeting enhancement and regeneration of construction supply chains, but then few have been substantially successful (Vrijhoef, Koskela and Howell, 2001:2).

In Nigeria, as discussed in section 1.1.2 a few studies on the cement industry focused on the inventory and challenges in transportation. For chemical and paint manufacturers customer satisfaction was appraised and the challenges facing the transportation system highlighted. This further confirms the dearth of research on construction material logistics management of manufacturers in Nigeria.

Afshan's (2013:326) study did note gaps in research on the relationship between logistics system integration and performance. Hälinen, Solakivi and Ojala (2013:134) suggested further study on the supply chain from a strategic point of view; one which integrates procurement, manufacturing and distribution within the organisation and the external supply chain partners and service providers. What does become clear is that there is insufficient knowledge of CSCM and logistics efficiency, affirming that the basic functional methods and strategies for effective CSCM is not clearly understood (Ying, Tookey and Roberti, 2013:154). Very little has been done to understand the current practices of construction material logistics management of manufacturers industries in Nigeria, even though this has the potential to improve the industry. A holistic study of construction material logistics management needed to be done on the Nigerian manufacturers.

1.3 Statement of the Problem

There is limited knowledge of the management of construction material logistics systems in Nigeria.

This is especially so in the industries that manufacture the construction material. We know a little and therefore, we have a little understanding of the construction materials logistics management utilised by Nigerian manufacturers. This research study investigated the management of systems used in materials logistics in North-Central Nigeria. Underlying this was the perception that any inefficiency in the delivery of construction materials will result in higher material costs and, in turn, higher construction costs. For this study, the management of construction material logistics is referred to as Management-CML.

1.4 Main Research Question

What is the effectiveness and efficiency of the management of construction materials manufacturers logistics systems in North-Central Nigeria?

From the above stated main research question, the following sub-questions were formulated:

1.4.1 Research Sub-questions:

Sub-question 1: What logistics channels do Nigerian construction materials manufacturers use?

Sub-question 2: What logistics systems do Nigerian construction materials manufacturers use?

Sub-question 3: How efficient are Nigerian construction materials manufacturers warehouse processes?

Sub-question 4: How efficient are Nigerian construction materials manufacturers transport systems?

Sub-question 5: What is the level of utility of technology by Nigerian construction materials manufacturers?

Sub-question 6: What is the level of customers satisfaction with construction material logistics delivery?

Sub-question 7: What strategies can be developed to improve efficiency and effectiveness of Nigerian construction materials manufacturers logistics?

1.5 Research Aim and Objectives

1.5.1 Research Aim

The research study aimed to measure the operational performance efficiency of the management of construction materials logistics used in selected construction materials manufacturers in North-Central Nigeria.

To achieve this aim, the objectives presented under 1.5.2 were formulated.

1.5.2 Research Objectives

Objective 1: To identify and examine the current logistics channels utilised by the Nigerian construction material manufacturers.

Objective 2: To identify the current logistics systems utilised in Nigerian construction material manufacturers.

Objective 3: To analyse the efficiency of warehouse processes applied to construction material manufacturers in North-Central Nigeria.

Objective 4: To evaluate the efficiency of transportation being used for the delivery of construction material from the manufacturer's plants to distribution warehouses, retailer stores and construction sites.

Objective 5: To determine the type and level of technology being used in logistics processes by the Nigerian construction material manufacturers.

Objective 6: To evaluate the level of customer satisfaction for the processing of order and delivery of construction material from the manufacturer plants to distribution centres/ warehouses, retailer stores and construction sites.

Objective 7: To develop a framework for efficient and effective construction material logistics management.

Table 1.1: The Relationship Between the Research Questions and Objectives

Research Sub-questions	Objectives
Sub-question 1	Objective 1
Sub-question 2	Objective 2
Sub-question 3	Objective 3
Sub-question 4	Objective 4
Sub-question 5	Objective 5
Sub-question 6	Objective 6
Sub-question 7	Objective 7

Source: Researcher's Construct (2019)

1.6 Importance of the Research

Global Construction Perspectives and Oxford Economics (2009:76) reported, on a global forecast for the construction industry over the next decade to 2020, that construction growth in Nigeria will be the fastest of all markets. If so, the effects of how construction materials are handled will play a crucial part in the organising and execution of building projects. This becomes more significant as the volume and scope of construction projects increase.

In the competitive business environment, there is an increasing demand for the manufacturers to process customer orders accurately, quickly and efficiently, while at the same time reducing inventory logistics. However, findings based on the few studies done on the management of construction material logistics systems (Management-CMLS) in Nigeria, established that there is little customer satisfaction, information flow is inefficient; too many inventory processes are used; there is limited automation; and transportation is a challenge. Manufacturers need to reduce activities that do not add value to their administration. They need to enhance client fulfilment, which is the main objective of logistics administration (Lambert and Cooper, 2000: 65).

Despite the significance of the cost of logistics systems, several organisations do not understand or address their operational components. More research examining the

importance of logistics systems needed to be done (Shakantu, 2005:301). If transportation costs absorb about 39% to 58% of logistics costs, then it would appear obvious that concentrating on savings in the transportation requirement would be essential. An investigation into the management of logistics systems would further establish what potential savings could be made. The recommendations of the study, if properly implemented, could improve profits for the logistics partners in the construction supply chain.

Studies referred to in Sections 1.1.1 and 1.1.2 focused mostly on the individual elements of the logistics system. They did not address the problems of inefficient and ineffective Management-CMLS as practised by the Nigerian manufacturers.

By considering the entire logistics system associated with moving a product from the point of production to the end user in an integrated manner, it is possible to advance a superior knowledge of logistics costs arising from the supply of a product. This would assist develop techniques that the supply chain can utilise to improve efficiency, be more organised and managed, and thus reduce these costs (Vidalakis and Sommerville, 2013:469; Andy, 2015:172). This study seeks to identify where to make operational changes in order to improve efficiency and effectiveness in logistics management. Such an enhanced logistics operation could result in reduction of cost, hazards and the financial sustainability of the construction process (Shakantu, 2005:44). It would also provide opportunities for all stakeholders to reduce their expenditure, earn higher profits and get better value for their construction clients (Vidalakis, Tookey and Sommerville, 2011:78). Consequently, this study seeks to improve on existing knowledge and proffer an understanding of Management-CMLS, where it is now, and how it can be made more efficient and effective by the Nigerian manufacturers.

There is little specific research providing a clear understanding of Management-CMLS as utilised by Nigerian manufacturers. Therefore, the point of departure for this study must necessarily be an understanding of Management-CMLS. This study is important because it provides the extent to which management of construction material logistics can reduce the cost of construction to the client. The study provides important guidelines for similar studies in other regions of the country and beyond.

1.7 Delimitations of the Scope of the Study

The prime elements of analysis in this research are the nodes and links in the logistics system, which is the organisation of the product (materials) flow from the initial manufacturer until delivery to the final customer. In addition, the study evaluates efficiency in the logistics processes; transport systems, warehouse systems and the level of customer satisfaction through it all. The study does not consider the inbound and production logistics. It is limited to the outbound (physical distribution of products) logistics management.

This research study focused on the North-Central Geo-political zone of Nigeria, which is one of the six geo-political zones in the country. The North-Central zone comprises six states and the Federal Capital Territory (FCT), Abuja. This study included five out of the six states, namely: Kogi, Nasarawa, Niger, Plateau, Benue and the Federal Capital Territory (FCT), Abuja. The rationale for the selection of Abuja is because it falls within the region and has a high concentration of construction activity. It is one of the fastest developing cities and has a spill over effect on the states with which it shares a common boundary.

The Management-CML of six industries were selected based on the following criteria: the likely representation of the manufacturers (not an uncommon, particular case in the sector), relevant market share, and interesting development in logistics (Voordijk, 2000:823). The materials manufacturers included cement, reinforcement bars (steel), ceramic tiles, crushed stones, hollow sandcrete blocks and sand (fine and coarse).

1.8 Key Assumptions of the Study

The research aims and objectives of this study guided the investigation. The assumptions made include the following:

i. Access to information required would not be hindered.
ii. All the elements of the logistics system for manufacturers to be sampled are in operation.
iii. The respondents are experienced and knowledgeable enough to provide reliable feedback on the data sought.
iv. Logistics systems may differ among manufacturers.

v. Responses would be received from representatives of manufacturers of construction materials, Logistics managers, warehouse managers, retailers, transporters, consumers and service providers. It is assumed that they represent the position of Management-CMLS as used by the Nigerian manufacturers.

1.9 Structure of the Thesis

This thesis is presented in seven chapters.

Chapter 1: This commences with an introduction and the research setting. It discusses the general performance of construction material logistics management as practised by the manufacturers globally and in Nigeria. The chapter also presents the research focus, formulation of the problem, statement of the problem and the main research question and Sub-questions. It formulates the research aim, objectives and justifications for the study. This is then followed by a delimitation of the scope of the study, the key assumptions and the structure of the thesis.

Chapter 2: This chapter provides an overview of Management-CMLS, including the logistics systems, concepts, elements and functions. The current operations and processes within logistics, including channels, transportation, warehousing, inventories, use of technology, automation and levels of customer satisfaction are discussed. The literature revealed that there are high inefficiencies in Management-CMLS.

Chapter 3: This chapter presents the theoretical basis of the research, which is anchored in the concepts of systems, efficiency and effectiveness of Management-CMLS. The chapter evaluates the fundamental concepts of effectiveness (maximising customer satisfaction) and efficiency (minimising the use of resources) of Management-CMLS used by Nigerian manufacturers. This sets the foundation for the development of a framework for effective and efficient Management-CMLS.

Chapter 4: This chapter discusses the methodology adopted for the research, and the reasons for the research method and associated instruments. It also assesses the various philosophical underpinnings of the research; the research paradigms and the

justification for the research philosophy and methodology. The chapter further describes the research design/strategy, data collection instruments and their validity.

Chapter 5: This chapter presents and analyses the research data. The first section discusses a brief background of the data collection method; the second section presents the individual case study data, and the third section is a summary of the combined data analysis.

Chapter 6: This chapter summarises the research findings. Strategies for effective and efficient Management-CMLS are presented.

Chapter 7: This chapter presents the summary of the research findings, conclusions and recommendations.

1.10 Chapter Summary

Chapter 1 presented a background of the Management-CMLS on a global and national perspective. Inefficiency was identified as a problem in logistics management. The research problem and questions that stemmed from the background were stated. The aim and objectives of the study were carefully formulated. This chapter also discussed the research delimitations, assumptions and presented the outline and importance of the study. The next chapter presents a review of the related literature on Management-CMLS.

Chapter 2: Review of Related Literature

2.1 Introduction

Chapter Two presents a theoretical background for this study. It discusses the definition and concept of logistics, the function and operation of logistics elements, logistics channels, customer service and customer satisfaction. All these factors form an integral part of Management-CMLS.

2.2 The Definition and Concept of Logistics

Logistics is the process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements. This definition includes inbound, outbound, internal, and external movements (Supply Chain Vision, 2010:72)

2.2.1 Phases of the Logistics Concept

Initially, logistics operations and processes were decentralised as inbound logistics, production logistics and outbound logistics. In other words, the distribution, procurement and production systems were independent of each other and each optimised their sole framework. However, with the application of the integrated logistics concept presented in Table 2.1, these independent logistics operations were integrated into a single logistics entity which was responsible for the entire logistics operation of a firm. The purpose was to eliminate any wasteful activity (Elena and Giacomo, 2001:4).

Early research on Management of construction material logistics systems (Management-CMLS) addressed the administration of transportation and warehouses. But currently, studies in logistics focus on two viewpoints: supply chain logistics, which deals with the movement of products, and service response logistics, which addresses the management of non-material operations that are essential for the fulfilment of an effective and efficient service. This includes cost efficiency and effective customer service (Gundlach, Bolumole, Eltantawy and Frankel, 2006:433).

Table 2.1: Definition and Evolution of the Logistics Concept

Phase Number	Logistics Types	Logistics Systems to be Optimised	Level of Logistics Integration	Focus on
1	Outbound logistics	Distribution system	Functional	Distribution
2	Inbound logistics	Procurement system	Functional	Procurement
3	Production logistics	Manufacturing system	Functional	Production
4	Integrated logistics	Logistics system	Functional	Firm
5	Supply	Channel logistics system	Functional	Channel

Source: Elena and Giacomo (2001: 4)

The Charter Institute of Logistics and Transport (CILT), (2012:14), defines logistics as "the time-related positioning of resources." Logistics is also described as the "Five Rights." It is the method of guaranteeing that a product or a service is:

i. in the right place;
ii. at the right time;
iii. in the right quantity;
iv. at the right quality, and
v. at the right price.

2.2.2 Logistics and Supply Chain Management

The Council of Supply Chain Management Professionals (CSCMP), (2013:2) "defined logistics as a major aspect of supply chain management that designs, executes and controls the efficient, effective, forward and reverse flow and storage of goods, services and related information from point of origin to point of consumption, for the purpose of conforming to customer requirements." Logistics management is concerned with optimising flow within the supply chain.

Management of a supply chain includes the evaluation of operations over various firms and processes, instead of taking the viewpoint of a single firm or process (Cutting-Decelle, Das, Young, Case, Rahimifard and Anumba, 2007:73). A supply chain comprises of all steps included, either directly or indirectly, in satisfying a client's demand. The complexity of the chain may differ significantly from industry to industry. It has been established that for better scheduling, and to understand the real benefits

of logistics, its focus should be on supply chain factors such as collaborations, as well as the level of relationship and coordination between chain partners (SteadieSeif, 2011:43). Management-CMLS of necessity must explore all these factors.

2.2.3 Nodes and Links in the Logistics System

In a logistics system, nodes are the spatial locations where products stop for storage or warehousing. The Nodes-Links System can be either direct or complex, depending on the number of nodes and links included. The focal point of this system is that links are multidimensional, attempting to keep up a reliable supply, reduce delay from manufacturers, and optimise inventory of materials for associated traders (Rushton, Oxley and Croucher, 2009: 48).

The concept of nodes vs. links is discussed more fully in Section 4.7.4 of this study. The concept provides the building blocks for the hypothetical structure on which the research design for Management-CMLS is founded.

2.2.4 The Concept of a Logistics System

At a fundamental level, any logistics system is a group of systems that has been planned, or coordinated, to create better services and performance than that realisable by individual systems (Jaradat, Adams , Abutabenjeh and Keating, 2017:4). Although there is no precise definition of a logistics system, there is agreement in terms of describing such a system as a purpose-built and connected set of elements (sub-systems), known as supply, production, transport, warehousing, inventory, order processing, packaging, materials handling and facility network design. It includes also the associations among them, and between their attributes, as these influence the flow of streams, financial resources and information (Gleissner and Femerling, 2013:22).

In a modest, transparent and understandable way Skowron (2001:233) established the classification of logistics systems, as presented in Figure 2.1. On reviewing the flow-chart, different divisions may be discovered that are hybrids of the systems shown in Figure 2.1. For instance, the worldwide logistics system and the emergency logistics system are such hybrids. However, this research study is focused on the functional

criterion. In terms of the functional criterion, one may extract the following logistics subsystems:

- stock creation system (inventory development);
- transport system;
- warehouse system;
- order realisation system (procurement and customer service), and
- packaging system.

These are further discussed in Sections 2.2.5 and 3.3.1.

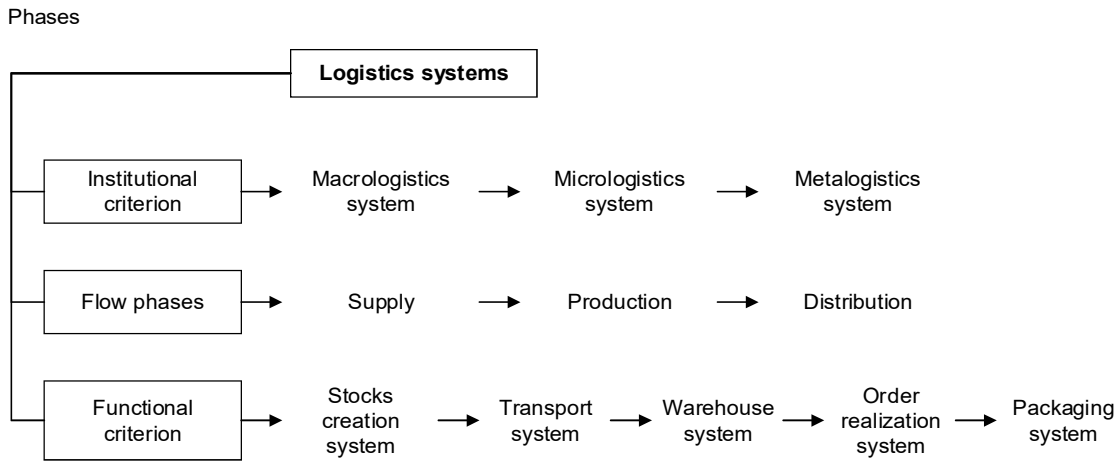

Figure 2.1: Kinds of Logistics Systems
Source: Skowron (2001:233)

As indicated by Bowersox, Closs, Cooper and Bowersox (2013:351), a few issues can be expressed concerning general system theory. In the first place, the execution of the entire framework or procedure is of significance. Secondly, focus is placed on the combined relationship between components that establish a system, instead of individual components having the best or optimum design. Thirdly, a functional relationship called 'trade-off' exists between components, one that serves to stimulate or hinder the total system performance. Finally, subsystems that are connected as a harmonised system may create final outcomes that are better than those accomplished through individual performance. For this Management-CMLS study, such integration becomes meaningful in the search for efficiency.

2.2.5 Logistics Systems in Collaboration and Integration

Supply chain scholars have analysed how harmonisation of firms, possibly by cooperating to organise labour and resources, improves proficiency and

effectiveness. The most widely recognised strategies which Supply Chain Management (SCM) researchers utilise to describe how firms organise their efforts are collaboration and integration (Jaradat *et al*., 2017:11).

Concepts of collaboration have varied over the years. However, the general thread running through the definitions is that collaboration represents "a culture of information, planning, risk, and reward-sharing, among firms with similar attitudes towards the nature of the relationship that they share, and their united efforts toward designing and adapting processes through which the participating firms may all prosper by more efficiently and effectively serving customers" (Jaradat *et al.,* 2017:11).

Scholars have wide-ranging views on their conceptualisations of integration. Their definitions have however, consistently included connecting procedures between firms working in partnership at both the tactical and functioning stages to achieve efficient and effective services for clients (Flynn, Huo and Zhao, 2010:58). They also noted the interconnecting business operations taking place both inside and between firms, especially those jointly working to attain mutual benefit, and those optimally coordinating movement of goods, management, data, cash and decisions (Jayaram and Tan, 2010:262; Huo, 2010:596; Sabet, Yazdani and De Leeuw, 2017:29).

Integration is the connecting of operations among and inside companies, on both the tactical and operative stages, including data, organising, inventory and sharing projections, with the objective of eliminating waste and duplication of effort while serving a customer better and more cost-effectively (Jaradat *et al.*, 2017:11). This kind of service is being sought by Management-CMLS.

In addition, coordination refers to a more direct, active cooperation. Contrasted with cooperation, coordination shows a collaborating, joint executive process, one where specific firm's influence each other's decisions more directly. Furthermore, there is horizontal coordination, which is cooperation within a supply chain tier, and vertical coordination, which is cooperation across supply chain tiers (for example, between supplier and customer).

2.3 Elements of Logistics Management

In summary, Figure 2.2 represents the typical elements (subsystems) of Management-CMLS as compiled by Islam, Fabian Meier, Aditjandra, Zunder and Pace (2013:5). The next section discusses the functions and operations of these elements.

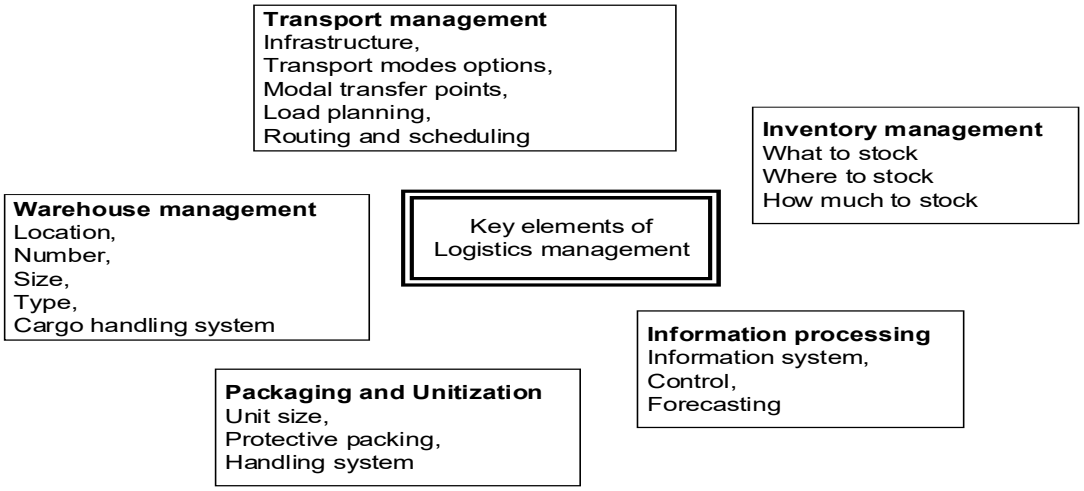

Figure 2.2: Key Elements of Logistics Management
Source: Islam *et al.* (2013: 5)

2.3.1 The Transportation System

The transportation system is the spatial link that joins customers, raw material suppliers, Distribution Centres / Warehouses (DC/WH) and channel partners in the Management-CMLS. Normally, transportation is a key cost element of the logistics supply chain (Shakantu and Emuze, 2012:661). Transportation costs constitute about 39% to 58% of total logistics costs and up to 4% to 10% of the goods marketing price for most firms (Coyle, Bardi and Langley, 2003:166). The key aspects of transport management include: means of transport, transport infrastructure, geographical landscape, kind of distribution (for example, night journey, normal, long hauls), load scheduling (in the freight unit), routing and scheduling (Islam *et al.*, 2013:5). The next sub-section discusses mode, load planning, routing and scheduling within the transportation system.

2.3.1.1 Mode of Transportation

The air, road, rail, pipeline and water mediums are the five basic forms of transportation. Electronic transport is referred to as the sixth mode of transportation (Ghiani, Laporte and Musmanno, 2004: 8; Ailawadi, and Rakesh, 2005:182). At least

one or more of these six different modes could be chosen for delivery of products to customers. All transport modes may not be appropriate or practicable for all business sectors and products.

How to assess and optimise joint plans to enhance sustainability and increase efficiency of multimodal transportation systems is still a great task (Song, Yin, Chen, Zhang and Li., 2013: 2274). If the road length goes beyond 350 kilometres, at that point railroad turns out to be more cost-effective than road transport. In the scope of 350-1000 kilometres, the monetary advantage of the railway delivery changes between 0% and 20% (Khooban, 2011:118).

Adesanya (1998:181) observed that the usage of roads is mainly a result of the natural advantage allowed by the presence of the huge land mass in Nigeria. The railways are not given enough consideration. Furthermore, road transport networks in Nigeria have high maintenance costs, both for the vehicles and infrastructure (Abimbola, Charles and Akinlabi 2014:1). Road transportation is also associated with delays resulting from heavy traffic, accidents and breakdowns on the way. Therefore, an effective and efficient transportation system is needed for business to function seamlessly (Abimbola, Charles and Akinlabi 2014:1). Management-CMLS would have to establish itself within this context.

2.3.1.2 Freight Transport

Freight transportation processes over long-hauls and among depots and towns may be done by rail, truck, ship, and so on, or in any mix of these methods. The structure of long-distance consolidation transportation systems comprises of an entire system with depots and associated connections.

Freight movement and its related negative effects have been progressively growing in many parts of the world (Fatemeh and Amelia, 2011:333). In Economics Studies, this is called the environmental cost of a process. Air, noise and water pollution; vegetation and wildlife destruction and road accidents are some of the negative impacts of freight transportation. Goods transport is a source of worry concerning sustainability problems, as road freight has adverse effects on the planet, people and profit (Quak

and De Koster, 2007:1103). Clearly, these concerns would have impact on Management-CMLS.

2.3.1.3 Vehicle Route and Scheduling Problems

The Vehicle Route Problem (VRP) is based on the concept of a specific set of roads identified for a fleet of vehicles which are based at one or some depots. This problem must be resolved first between the various geographically spread towns and customers. The goal of the VRP is to provide a minimum cost to a set of customers with known demands, presenting specific warehouses as the beginning and ending of vehicle routes. The optimised roads have an important effect on the transport business, as they decrease the costs and travelling time. Studies show that by improving the transport system through optimising the routes, a saving of transportation costs of up to 20% is possible (Kavran, Jolic and Cavar, 2009:335). Such studies have great relevance for Management-CMLS.

2.4 Transportation Operation Management

This section presents the related transport operations management for Management-CMLS. These include requirements for transportation, whether trucks should have empty or part loads and delivery frequency systems.

2.4.1 The Requirements for Transportation

Contrary to the construction industry, the manufacturing industry can choose where they should conduct their productive operations. The companies are sited on fixed locations, hence the need to move their products to where their customers are. This brings transport into the core of the city and built up areas. Construction material transport costs include capital, as well as operating costs. The capital cost depends on the make and type of vehicle. Apart from capital or purchase price, vehicle owners also operating costs, which can be classified as fixed (overhead) and variable costs. These are summarised by Pienaar (2016c:386). He clarified that the fixed costs relating to road transport are:

- Land and buildings (premises, offices and warehouses);
- Terminal facilities (vehicle depots, parking areas, garages, fixed loading and consolidation facilities and equipment);

- Corporate management, administration, supervision, ongoing training costs, other corporate support functions; and,
- Insurance covering assets other than those covering the vehicles and corporate risk.

Variable costs consist of running costs and trip-specific operating expenses. Running cost items for road transport comprise fuel consumption, tyre wear, engine oil consumption and maintenance. These costs are caused by vehicle movement and cannot be avoided when a vehicle is in motion. The trip-specific operating costs are expenses that might be incurred on certain trips, regardless of the distance covered or specific operating conditions experienced (for example, trip documentation, and loading and offloading at trip ends). The fixed and variable cost items presented by Pienaar (2016c:386) would apply to Management-CMLS.

2.4.2 Empty Vehicle Movement

Running an empty vehicle is necessary at times because of regional demand differences, scheduling restrictions and vehicle incompatibilities (Lambert, Riopel and Abdul-Kader, 2011:565). A study by the United State Census Bureau Service (2010:14) revealed that 20% of truck movements were empty runs (these numbers differ by type of vehicle) in the United States. In Europe, the figures are more than 30%. Once empty runs occur, then labour, fuel and running costs must be charged against the forward movement. McKinnon and Ge (2006:391) recommend that vehicles should transport materials on their return journeys as well. However, they noted that this was not always possible for the following reasons:

- Deficiency in harmonisation between procuring and logistics departments;
- Unpredictability of collection and transport operations;
- Precedence given to the distribution service;
- Insufficient information of available loads;
- Mismatch of trucks and goods; and,
- Capital limitations.

In spite of these constraints, reducing empty movement is possible and it is an effective method to cut the external cost of load delivery (Fatemeh and Amelia, 2011:334). To address the problem of vehicles running empty, transport providers are

working in partnership with other transport providers in similar or dissimilar companies to share their vehicle size needs, or to create round trips and continuous moves (Ruamsook and Thomichick, 2012:137). As one of the transporters, Macy's had the capacity to provide over 328 loads on the Empty Miles site and discovered extra transporters for 70 of its empty truck routes (Belson, 2010:24). A study on the reasons that led to reduction in running empty vehicles by McKinnon and Ge (2006: 394) concluded that the following changes worked effectively:

i. They contracted out the haulage from in-house to third-party transport providers.
ii. By improving on regional stability in vehicles movement through the broader sourcing of products, centralisation of manufacturing and inventory and better provincial specialisation.
iii. By raising the standard distance of transport routes.
iv. Through reducing the direct cost of transporting (fuel, labour) per kilometre.
v. By improving on the number of stops (for collection or delivery) per trip.
vi. By creating reverse logistics (wrapping waste, handling equipment and product into existing logistics systems).
vii. By creating load-matching management of materials through online freight data exchange agreements.

Note that all the above recommendations have meaning for Management-CMLS.

2.4.3 Delivery Frequency System

The Delivery Frequency System can be classified into three methods, namely customised transportation, consolidation transportation and frequent operation (Taylor, 2008:132).

2.4.3.1 Customised Transportation

In the customised transportation approach, Truck Load (TL) or Full Truck Load (FTL) trucks with a driver or driving crew are dedicated to a buyer. Under these situations, shippers should endeavour to use their own resources, such as crews, fleets, vehicles and trailers in the most suitable manner so as to respond to the most extreme requests of the shipment process (Khooban, 2011:112).

2.4.3.2 Consolidation of Transportation

Broadly, there are four methods for consolidating traffic. They are load, route, trip and loading point consolidation, all of which are aimed at achieving either economies of density and/or scope and/or distance (Schumer, 1974:176).

Consolidated transportation is one approach to reducing transportation costs. The aim here is to exploit Economies of Scale in delivery by replacing large deliveries with small ones. Consolidated transporters carry out shipping operations by using various types of transport: railcars, trailers, containers and ships, among others (Khooban, 2011:112). Consolidation deliveries for some construction materials rely upon the capacity of trucks. An important factor in the operation of this system is that contractors and suppliers can arrange transport bargains based on the size of trucks. For instance, crushed stones and sand are usually loaded dependent on the size of a truck (Hoff, Andersson, Christiansen, Hasle and Lokketangen, 2010:2042). This is connected to the capacity of the organisation to ship large quantities of orders while handling a smaller number of vehicle movements. Thus, it is directed by the connection between the number of transportations satisfied by a solitary truck delivery, and the pertinent distance travelled (Vidalakis and Sommerville, 2013: 478).

An overview of Management-CMLS suggests that producers take responsibility for their own deliveries. Most construction material producers have their own dedicated vehicles and distribution schedules, delivering 'ad hoc' to several places. Subsequently, the technique most commonly used to transport materials to construction sites is that of dedicated, single use vehicles such as cement and concrete trucks from manufacturer's plants to points of consumption on sites (Shakantu and Emuze, 2012: 667).

2.4.3.3 Frequent Operation

From an economic viewpoint, transporters must organise the frequency of operations between any two points. Discovery of most suitable shipping incidence can lessen funding in equipment and facilities (Khooban, 2011: 112).

2.5 Reverse Logistics

The CSCMP (2013:114) defines reverse logistics "as essentially the opposite of logistics." George, Huanqing and Zhaomin (2010:52) identify the various types of reverse logistics according to their return trip reasons and classify them into the three main supply chain phases in which they occur. These are manufacturing returns, distribution returns and commercial returns, all of which include damaged goods and incorrectly ordered goods. The main difficulties for companies and supply chains is cutting down the cost of reverse logistics. Most organisations do not appreciate the working expense of profits since these expenditures frequently turned out to be covered up in the monetary details of business operations (Mollenkopf, 2010:1). Hidden charges remain a relevant factor in decreasing profits. Of critical relevance to Management-CMLS is what Walden (2005:653) outlined as hidden costs, including the following:

i. Credit of goods to the customer, where the damages are not covered by the supplier under guarantee.
ii. Costs of preparing the returns to the distribution centre.
iii. Transportation charges for moving the materials/ goods back to the company.
iv. Costs of testing and repackaging materials.
v. Storage costs in the warehouse.
vi. Disposal costs if the items are damaged beyond repair.

2.6 Outsourcing of Transportation

Outsourcing logistics providers, usually called Third-Party Logistics (3PLs), "offer their clients numerous logistics services, such as cargo forwarding, packaging, transportation and inventory management, as well as warehousing and cross docking" (Hannan,2011:13).

One must consider why firms outsource logistics. While it is not considered a main function/skill, it should be taken care of more professionally. This would then lead to reduction in logistics costs; provision of access to IT expertise, equipment and skills; enabling access flexibility in capacity, and variable cost due to increasing or falling customer demand; removal of logistics assets from the balance sheet and it would free up capital (Seyed-Alagheband, 2011: 76).

Notwithstanding the many merits of using 3PL, there are some negatives as well. For example, it is difficult to find a dependable and cost-effective company that acts between the shipper and the 3PL provider. If a manufacturer outsources logistics operations, it risks losing experience in logistics (Seyed-Alagheband, 2011:76). Also, manufacturers outsourcing their logistics processes are often concerned about the security of organisation data since they need to communicate private records with that firm (Van Damme and Van Amstel, 1999:85). Nonetheless, the utilisation of third-party transport providers has developed substantially over the last few decades and this appears to be cost-effective to customer (Deepen, 2007: 28). The skill of Third-Party Transport service provider (3PT) to sustain a progressively related role in current supply chains is to a great extent motivated by their continual capability to offer benefit to their clients. This value emerges from attaining customer desire in a most profitable way than can be accomplished by manufacturers executing the operations themselves (Deepen, 2007: 28). Whether this proves true in the Nigerian context is significant in this study on Management-CMLS.

2.7 Vehicle Condition

In Nigeria, most vehicles are either diesel or petrol driven. Nevertheless, the trucks cannot stay in permanently good condition, as the parts break down and wear out, and so, must be maintained. Maintenance is defined as the repair activity carried out on vehicles or other machinery to keep them unaltered, and if altered, to restore them to their original state. With effective maintenance, all such systems can basically remain in good condition and be operational (Adebumiti and Muhammed, 2014:241). Researchers such as Steyn and Bean (2011:30) attribute a rise in truck repair and maintenance costs to the worsening road conditions in many countries. This could create an increase of about 10% in the entire logistics costs of an organisation. Additional costs that could be related to worsening road conditions are rises in vehicle working expenses, rising fuel consumption, increased load damage and increased vehicle design and manufacturing costs (Steyn and Bean, 2011:30).

2.8 Transportation Inefficiency

It is essential to understanding the flow of transportation as it is a key contributor to cost, and therefore to cost control and reduction. Current knowledge of logistics in Management-CMLS is inadequate, especially with transportation. More attention is

paid to Supply Chain Management (SCM) without corresponding interest its pre-eminent subsets, such as the transportation system (Shakantu and Emuze, 2012:661). The fundamental reason behind the emphasis on SCM is that the organisational structure of the construction industry appears to hinder the development of efficient logistical systems (Van Herk, Herder, De Jong and Alma, 2006:187). A further difficulty is that the delivery of construction material from the point of manufacture to the point of utilisation is not harmonised and not adaptable (Vogt, Pienaar and de Witt, 2002: 222).

Andrejić, Bojović and Kilibarda (2013:3926) identified five points that cause transportation loss or waste. These are driver breaks, excessive loading time, fill or cargo loss, speed loss and quality delay. This inefficiency is measured in terms of the number of vehicle deliveries that include fewer truck loads, the distance travelled, and the amount of time spent waiting on-site all key targets for improvement through the application of LEAN reasoning. LEAN methods focus on efficient and effective processes. In Management-CMLS, this would mean encouraging less full loads and improved harmonisation on-site to lessen idle times (Fearne and Fowler, 2006:283). Operationally, there appears to be many options to use waste removal methodologies. The lack of interest in using them is the problem, despite the possible benefits.

2.9 Warehousing

The discussion so far has focussed on transportation, which principally take place on system links. However, warehousing and material storage mostly takes place at nodal points (Hannan, 2011:30; Ramaa, Subramanya and Rangaswamy, 2012:19). Previous studies have revealed the effects of different warehouse characteristics, such as “ownership, region location, lay-out, size and level of automation”. All these factors speak to warehouse performance (Banaszewska, Cruijssen, Dullaert and Gerdessen, 2012:484; Andrejić, Bojović and Kilibarda, 2013:3926). The next sections discuss the location and structure of warehouses, layout, size, operations and processes and their management information systems.

2.9.1 Location and Size of Warehouses

The “100% location” is a typical expression among specialists who identify that a location for each store serves optimal purposes. Since different retailers need different

types of locations, a fully optimised place for one store might not be suitable for others (Afshari, and Benam, 2011:276). There is no uncertainty that the drive to multi-channel transaction is affecting the number and size of warehouse operations (Gwynne, 2014:219).

2.9.2 Warehouse Layout

Warehouses have different distinctive outlines as per the product specification, customer requirements and the service level offered. A standard warehouse is illustrated in Figure 2.3. The middle part of Figure 2.3 displays the basic arrangement of the warehouse, with the following sections: “receiving docks for inbound trucks, offloading area, inventory area, packing and shipping area and delivery docks for shipment” (Staudt DiMasloco, Alpan and Rodríguez, 2014:22). Since most DCs use people for order picking, this warehouse follows a manual system for storage and picking products (De Koster, Le-Duc and Roodbergen, 2007:484). In the manual system, the request picker/ forklift driver must store items in an appropriate area (in the event of capacity) or stores the goods in racks (in case of order picking), as explained by Staudt DiMasloco, Alpan and Rodríguez (2014:22).

The inventory area of Figure 2.3 serves as the reserve storage area and the forward picking area. The stockholding zone contains the bulk stock and it has superior rack levels. The forward picking zone is in the same racks as the bulk stock, but on the inferior levels to facilitate the order picking process. This zoning implies regular internal replenishments from the reserve to the forward area (Staudt DiMasloco, Alpan and Rodríguez, 2014:22) .

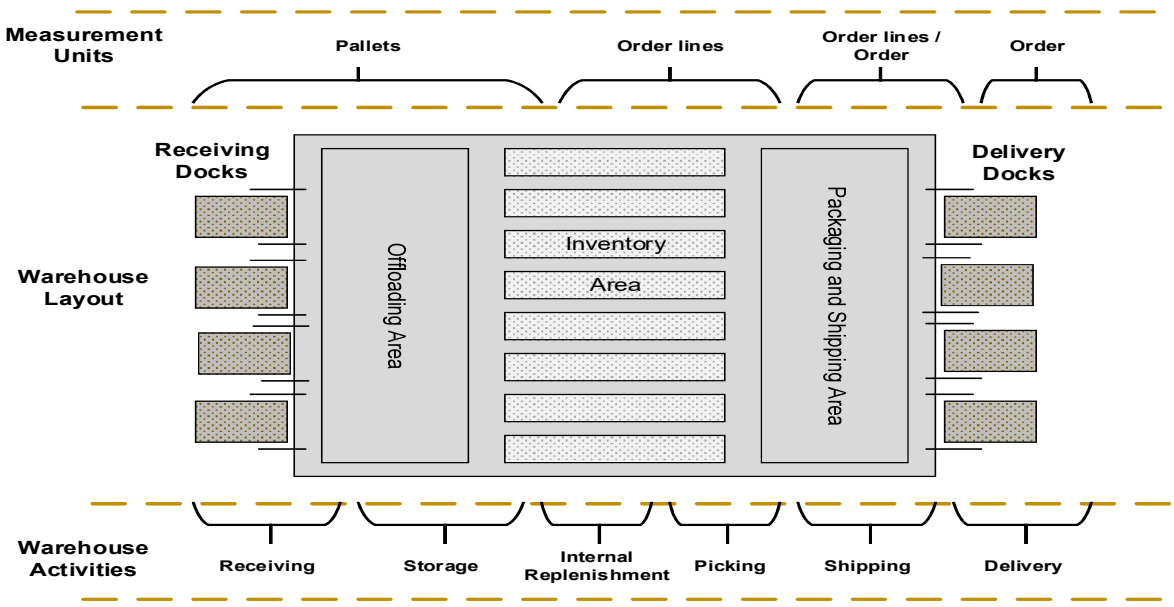

Figure 2.3: A Typical Standard Warehouse Layout
Source: Staudt DiMasloco, Alpan and Rodríguez (2014:22)

2.9.3 Warehouse Operations and Processes

The warehouse processes include pre-receipts, receiving, put-away, storage, order picking, packing, loading, stock counting, value adding services and other activities (Gwynne, 2014:68). According to Chen, Cheng and Huang (2013:3392), "the overall receiving, storage, picking, sorting, packaging and shipping processes in every warehouse consists of 30 steps." Among these undertakings, stockpiling and request picking are the most expensive. Storage requires stock holding (one of the eight types of wastes), and order picking requires a great deal of work hours (which is specified as an alternate sort of waste) in the study by Rouhollahi (2011:55).

In summary, present warehouse processes in both Central Distribution Centres (CDC) and Local Distribution Centres (LDC) are ineffective due to bottlenecks, copious amounts of paper work and slow manual operations. All of these lead to small amounts of work done, long lead time and high labour costs (Ramaa, Subramanya and Rangaswamy, 2012:19; Chen, Cheng and Huang, 2013:3392).

2.9.4 Warehouse Management System (WMS)

Presently, WMS is a record driven computer application that improves the effectiveness of the warehouse by coordinating cutaways and keeping up correct inventories by recording warehouse operations (Bartholdi and Hackman, 2014:1). The

main objective of a WMS is to achieve the targets of warehouse management, to improve management levels and to optimise the utilisation of space, instruments and labour. It controls and maximises inventories by updating records about the status of container usage. The efficiency of a WMS in a warehouse ensures a production performance that is higher than when the processes are done manually (Ramaa, Subramanya and Rangaswamy, 2012:20).

Ramaa *et al*. (2012:18) summarised how performance improved on implementation of the WMS application as follows:

i. Time planning of vehicles is possible. This lessens the waiting time of the supplier.
ii. With advanced delivery notes, the Distribution Centre has prior data about the materials it is about to receive.
iii. WMS helped the process of storage of goods.
iv. 100 percent tracking of products was possible.

2.9.5 Packaging and Unit Loads

Packaging and unitisation are similarly central features of logistics. The main essentials of packaging and unitisation comprise the kind of , cost and other essentials that are related to the value and sort of product. From a packaging viewpoint, the greatest significant issues that influence transportation costs are volume, stowability and handling, because these factors are highly influenced by a product's physical characteristics (Parvini, 2011:172; Islam *et al.*, 2013:3).

A quick checklist that adequately addresses the packaging requirement typically contains all of the following (Niggi, 2017:52).

i. Packaging weight and dimensions;
ii. Carton labelling requirements;
iii. Cartons materials;
iv. Packing and assortment method; and,
v. Retail packaging graphics and labelling.

A unit load joins singular product, or products in delivery containers into single "units" that can be shipped effectively with a pallet jack or forklift truck. Pallets are an

essential part of any supply chain. They guarantee the effective delivery of items so that there is insignificant harm to products. Pallets make it simple to move substantial stacks. The returnable pallet system is run by pallet rental organisations, where the pallet users need not own the pallets and have simply to pay the lease for utilising them. Along these lines, pallets are utilised by various clients, which empowers conservative and productive use of assets.

The manufacturer's use and discarding of packaging represents about 60% of entire manufacture costs, or between 15% to 50% of the selling cost of an item. From this, packaging can be seen to be closely associated with logistics operations (Ailawadi, and Rakesh, 2005:120). If the package is not planned correctly, the efficiency of the logistical system drops. The size angle affects the utilisation of a warehouse. Additionally, size influences the number of items that can be shipped at the same time.

2.9.6 Warehouse Automation and Equipment

Automation principle of material handling is that the operations should be "mechanised and/or automated where feasible to improve operational efficiency, increase responsiveness, improve consistency and predictability, reduce operating costs, and to eliminate repetitive or potentially unsafe manual labor" (Material Handling Institute (MHI), 2000:22).

Many researchers have discussed warehouse automation from different perspectives. These include warehouse technology, workshop equipment, warehouse systems and factory equipment (Kay, 2012:20). Industrial doors and gates, Forklift Trucks and Accessories and Automated Guided Vehicles (AGV) were noted by Rushton, Croucher and Baker (2006: 124) and Gwynne (2014: 220). Automated Guided Vehicles (AGV) are extensively used to move goods and materials to different parts of a manufacturing plant and are one of the most efficient and appropriate ways. Autonomous mobile robots (AMR) are fundamentally different although, it will eventually allow automation to a great extent keep the flexibility and versatility of human-operated vehicles (Ghaffarzadeh, 2018:22). The difference between AGVs and AMRs are as following (FoodMach, 2019: 16)

i. AMR's are different from AGV in their level of autonomy

ii. Automated systems are designed to perform a set of repetitive tasks by following pre-defined instructions with minimal or no human intervention

iii. Autonomous systems, on the other hand, are not only able to perform defined tasks automatically but also have the intelligence to make independent decisions in 'never-seen-before' scenarios.

2.9.6.1 Material Handling Equipment

Material handling is a vital element of the 'supply chains which involves a variety of operations including the movement, storage, protection and control of materials and products throughout the processes of manufacturing and distribution' (Horňáková, Jurík, Chovanová, Cagáňová and Babčanová, 2019:1). The suitable handling equipment could be selected based on the entry requirements and conditions of the enterprise and trends in material/final product handling towards increasing automation, enhancing productivity and maximising safety (Horňáková *et al.*, 2019:2).

Warehousing, storage and material-handling operations, which are frequently referred to as "transportation at zero miles per hour," accounts for about 20% of total logistics delivery costs. Consequently, they force logistics managers to give them serious attention (Ballou, 2004:76). And they have special significance for Management-CMLS analysis through this study. Material handling consists of "short-distance movement that normally take place inside a building; for example from a plant or a distribution centre and between a building and a transportation organisation" (Kay, 2012:20).

Each point of stockholding encompasses handling of the materials. The more times material is handled, the more the overall logistics costs add up as the process still comprises both equipment and human effort (Michael, 2015:16). The cost of labour in the warehouse/ store includes the effort to receive, put away, move, check and count inventory.

2.9.6.2 Order Picking Methods

Order picking is the area where the progress in technology have changed the picking activity and improved precision and efficiency meaningfully. The utilisation of

barcoding, voice technology and pick by light systems isn't just improving distribution center picking tasks it is additionally, creating an adequate rate of profitability (Gwynne, 2014: 93). The picking techniques that are, as of now, being used in distribution centers incorporate paper pick list, pick by the label, pick by voice, barcode scanner, radio frequency identifciation, pick light/pick to light, put to light and automated picking (Gwynne, 2014:93).

2.9.6.3 Storage Equipment/ Methods

In terms of storage systems, the compromise is between speed, cost and capacity. The compromise is in the way that these systems take time to access and store pallets and may need precise dealing with equipment or an alternative kind of racking. Wide walkway flexible pallet racking, instead, occupies more floor area but goods are easier and faster to access (Gwynne, 2014:221). There are several kinds of pallet racking arrangements being used at present. These comprise floor /block storage, single deep racking, double-deep racking, push-back racking, drive in/through racking, powered mobile racking, narrow aisle racking, simple-deep (Automatic Storage and Retrieval System (AS/RS)), double-deep AS/RS, more than two deep AS/RS and others (metal stillages). Every storage methods has its merits and drawbacks as fully discussed by Gwynne (2014: 221).

It is important to choose the most appropriate equipment, especially so for Management-CMLS. The cost of inappropriate equipment includes not only the capital sum, but also the consequent reduced efficiency and effectiveness of the operations (Vogt and Pienaar, 2016:324).

2.10 Inventory

An inventory can be defined as 'the stock held in reserve between any two processes for uninterrupted operation' (Mausmi, 2012:34). Inventories are kept principally for two reasons: "to improve the sourcing cost (where conditions are predictable) and to decrease the danger of stock running out (where circumstances are uncertain)" (Mausmi, 2012:34). A basic inventory contains the vital choices of "what to stock, how much to stock and where to stock" (Islam *et al.*, 2013:3). Inventory administration is sometimes confused with warehouse management, inventory administration is about

the quantity of stock of the merchandise or raw material, while warehouse management controls storing and material handling processes (Islam *et al.*, 2013:3).

2.10.1 Inventory Management and Control

Inventory control guarantees the supply of the desired quality of stock at the required time, thus preventing needless investment in inventories. Inventory Management Optimisation (IMO) software designs are proactive planning devices to enhance stock levels and the utilisation of site /warehouse space and transport operations (Jimoh, Olakunle and MCNay, 2015:57). The software is planned to transport materials to the right place at the right time, with supply measured against actual and estimated demands for each supply centre. There are many inventory management systems mentioned in a study by Jimoh *et al.* (2015: 57) and these include:

i. Vendor Managed Inventory (VMI)
ii. Quick Response (QR)
iii. Synchronised Consumer Response (SCR)
iv. Efficient Consumer Response (ECR)
v. Rapid Replenishment (RR)
vi. Centralised Inventory Management (CIM)
vii. Continuous Replenishment Policy (CRP)
viii. Collaborative Planning, Forecasting and Replenishment (CPFR).

The two major collaborative strategies for managing inventory levels are VMI and CPFR.

2.10.2 Vendor Managed Inventory (VMI)

Vendor Managed Inventory (VMI) is nonstop replacement or supplier managed inventory. It is the most widely utilised collaboration system for teamwork and data sharing among business associates (Sari, 2008:495). The retailer provides the space and service level conditions, and their responsibilities are to share sales and inventory information. In an ordinary VMI programme, vendors manage the request estimating process (Cronje, 2016: 250).

2.10.3 Collaborative Planning, Forecasting and Replenishment (CPFR)

CPFR is perhaps the most commonly used collaboration effort between supply chain members. CPFR is a procedure that was introduced by the Fast-Moving Consumer

Goods (FMCG) industry to harmonise the individual forecasts of numerous associates in the supply chain. Rather than retailers, distributors, manufacturers, transport providers (and some other members in a particular supply chain) each making their own estimate, they share, deliberate, organise and justify separate plans to create a joint plan (Cronje, 2016: 250). This is a business practice that joins intelligence from numerous business partners to collectively work on meeting customer demands (Sari, 2008:498). It enhances the supply chain by decreasing inventory and fulfilling customer requirements by achieving an improved corresponding balance of demand and supply, so the influence on Management-CMLS is central to this study.

2.10.4 Inventory Consideration for Construction Supply Chains

In respect of inventories for the construction supply chain, Vidalakis, Tookey and Sommerville (2011:71) noted three crucial facts which differentiate construction Supply chains. They are connected to both the material and information flow and influence all the firms in the chain. These are:

i. The Contractors' ability in handling inventory is limited (and at times deficient);
ii. The Contractors' requests are not communicated upstream unless the project is ordered; and,
iii. The Contractors do not assess a request for material before the contract is approved.

It is limitations of this nature that speak directly to the Management-CMLS.

2.10.5 Inefficiencies in Inventory

The inefficiencies in inventories include excessive content, poor product forecasts, measurement inconsistency, excesses, inaccurate planning and the high cost for small deliveries (Lee, Padmanabhan and Whang,1997:546). This becomes visible at construction sites, where ordering and shipment processes cause delays due to the lack of material and/or extra costs because express deliveries have to be made (Vidalakis, Tookey and Sommerville, 2011:71).

2.11 Technology

In the field of logistics, diverse new technologies are utilised in developed nations, while this adoption is extremely slow in developing countries. The level of technology

differs vastly, and the range can go from remarkably vital installations with high manual effort and minimum computerisation, to completely mechanised and robotic installations (Bhandari, 2013:21). The latest advanced technologies being adopted in logistics and supply chain management are categorised as Automatic Identification Technology, Communication Technology and Information Technology (Bhandari, 2013:21).

2.11.1 Automatic Identification Technology

Automatic Identification (Auto ID) technology is the term used to describe the direct inputting of data or information into the computer system, where programmable reasoning controllers or any microprocessor-controlled device is used without operating a keyboard (Bhandari, 2013:21). The data capturing tools are optical scanning, electronic-pen notepads, voice recognition and robotics. Electronic Data Interchange (EDI), Electronic Fund Transfer (EFT), intranet, internet and extranet enable such technology (Asadi, 2011:233; Quesada, Gazo and Sanchez, 2012:36). Additionally, the tools include Bar Coding, RFID and voice recognition (Bhandari, 2013:21). Smart cards, magnetic strips, vision systems and positional systems (GPS-MPSGIS-Navigator) form part of technology as well (Gourdin, 2005:122; Asadi, 2011:233). The benefits of Auto ID are accuracy, cost saving, speed and convenience of data storage and processing of information (Bhandari, 2013: 21). Critically, each of these factors contribute to the analysis of Management-CMLS.

2.11.2 Communication Technology

All communication, whether oral or written, plays an extremely critical part in business accomplishment. Bhandari (2013:22) noted that communication technology facilitates better customer service, leading to competitiveness through the speed and accuracy in the communication. He identified the developing communication technologies as follows: Electronic Data Interchange (EDI), Very Small Aperture Terminal (VSAT), Geographical Positioning System (GPS), Geographical Information System (GIS), Automated Guided Vehicle System (AGVS), Information Directed System (IDS) and web-based tracking.

Furthermore, other basic communication software used in logistics and supply chain management are: Material Requirement Planning (MRP), Manufacturing Resources

Planning (MRPII) and Enterprise Resource Planning (ERP). Another kind of communication device is the World Wide Web (WWW), a uniform interface that permits worldwide exchange of information through the use of browsers (Quesada, Gazo and Sanchez, 2012:36). The use of communication technology software is a tactical plan that enhances a firm's effectiveness, permitting cost decrease and enabling efficiency (Quesada, Gazo and Sanchez, 2012:36; Ramaa, Subramanya and Rangaswamy, 2012: 14).

2.11.3 Information Technology (IT)

Information Technology (IT) comprises the hardware and software that collects, analyses and gives information wherever it is required. If the supply chain management is defined as a system of firms, these companies cannot work as a team unless they are linked through IT. This would provide transparency in the supply chain and align the supply chain activities for the benefit of the customer. The IT tools adopted in logistics and supply chain management are Enterprise Resource Planning (ERP), Distribution Requirement Planning (DRP), Automated Inventory Tracking System (AITS), CPRF and Web-based collaboration (Bhandari, 2013:24). In earlier times, logistics was more manually rigorous and there was zero ability to monitor and track the delivery of goods. Nevertheless, with the dawn of IT and technologies such as RFID and GPS, complete visibility in movement of goods is assured, thus resulting in efficient logistics and warehouse management (Bhandari, 2013:24). The impact on Management-CMLS is transformative and justifies the need for this study.

2.11.4 E-Business Application

Matopoulos, Vlachopoulou and Manthou (2009:6) classified e-business application complexity as inclusive of Internet access, E-mail, Website, Intranet, Selling-buying online, Extranet, E-banking, E-marketplace and Collaborative Platforms. Advancement in e-business adoption and impact result in enhanced operational reliability and improved levels of partnership. With respect to e-business impact, this for the most part is about process duration reductions and quality enhancements, rather than direct cost reductions as reported by other researchers (Matopoulos, Vlachopoulou and Manthou, 2009:1).

The benefits of IT include accuracy, ease of identification of inventory items during storage, retrieval, pickup, inspection and dispatch. It reduces paperwork and operation time leading to limited cause for human error, and increases the efficiency of the logistics system through speed, accuracy and dependability (Hu, Shi, Voß and Zhang, 2011: 209 ; Eckhardt and Rantala, 2012:614).

2.11.5 Inefficiencies of the Technology in Supply Chain

Cutting-Decelle *et al*. (2007:80) found much evidence to prove that efficient sharing of records is not progressing within industry supply chains. They confirmed that:

i. Manual record entry is common, notwithstanding that machine sources are accessible; basic data is regularly physically re-entered at many points in the chain.
ii. Better involvement of procuring clerks, order processors and expediters is required to keep up inventory network data streams.
iii. The use of decoders to convert data from one format to another is almost universal, even between systems that are supposedly consistent with built up conventions. However, this technology is not sufficiently applied.

Generally, machines are not being sufficiently used to reduce human errors and are not well coordinated with project management systems to make monitoring and tracing of materials easier and quicker (Kasim, 2015: 218).

2.12 Logistics Channels

There are different outbound logistics channels that can be utilised independently or in combination with each other to bring goods or materials to the end-user (Hoff, Andersson, Christiansen, Hasle and Løkketangen, 2010:2051; Hannan, 2011:27). Logistics channels are connections of middle parties or indirect marketing channels engaged with delivery, storage, handling, communication and supplementary roles that add to the efficient flow of material (Palvic, Host and Nuhanovic, 2016:22). Outbound logistics is a link connecting the production area with the consumption area and its task is to bridge the gap between these two stages. The gaps refer to time, space, quantity, range of products and information (Szymonik, 2010:129).

Although intermediaries add a mark-up to the cost of material, they are of benefit to the manufacturers and customers. They provide specialised outbound logistics functions, improve product assortment and increase transactional efficiency (McKinnon,1989:27). The benefits of intermediaries include outbound logistics services that are handled more effectively than manufacturers can. They operate more economically than single manufacturers because they change over the varieties of products made by manufacturers into the varieties requested by the customers (Hannan, 2011:29). Additionally, the key economic benefits are 'reducing lead times, delays and entire transportation costs, as well as improving efficiency, reliability and quality' in the administration of all systems (Hoff *et al.,* 2010:2061).

Figure 2.4 indicates the primary alternative logistics channels compiled by Rushton, Croucher and Baker (2006: 146) and Boone, Kurtz, MacKenzie and Snow (2010:390). The physical shipment of materials between channel members is outlined by the hand-shaped symbols in the figure. Although these channels are mainly for consumer products, industrial marketing channels are quite the same (Hannan, 2011:28). The number of these middle men can be reduced by adding an intermediary (an agent or broker, a wholesaler, or a retailer) between manufacturers and end-users. Consequently, the existence of intermediaries can remove the duplication of efforts of both the manufacturers and customers and increase the effectiveness of the outbound logistics system (McKinnon,1989:27).

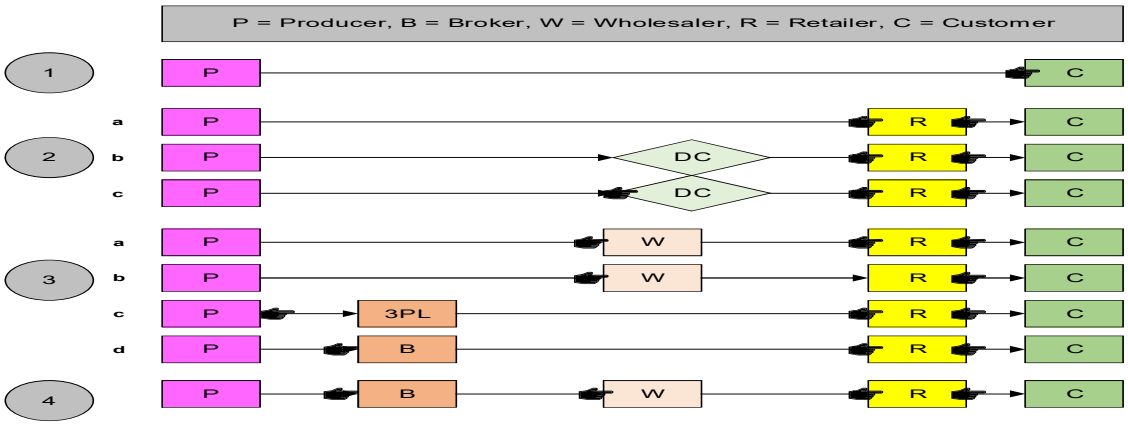

Figure 2.4: Alternative Outbound Logistics Channels
Source: (Rushton, Croucher and Baker, 2006:146; Boone, Kurtz, MacKenzie and Snow, 2010:390).

Clearly, these developments speak directly to Management-CMLS. In similar ways, Builder Merchants (BM) and Material Suppliers (MS) are situated at the nexus of the movement of construction materials from the manufacturer plant to the point of utilisation or the construction site. In this way, BMs have a two-route flow to achieve, both upstream (cash and data) and downstream (materials). From a micro scale perspective, the effectiveness of logistics depends on the time and distance between the nodes of the system, for example, the proximity of MS and BM to construction sites (Vidalakis,Tookey and Sommerville, 2011:73). Thus, the cost of construction material may increase as a result of the presence of the middle people in the material shipping process, but from an overall perspective, when compared with producers, such intermediaries do profit users by reducing the transportation unit cost (Khooban, 2011:111).

However, there is a drive to 'omni-channel' retailing, which is a more all-in-one approach to consumer knowledge through all shopping channels, including the internet, stores, direct mail and so forth (United States Postal Service, 2013:6). Harris (2013:6) recommends that moving to online business could enhance performance and decrease transaction costs. Consumers will then have the capacity to order materials for delivery to sites, check prices, specifications and stock level online, while then being also able to visit nearby offices or stores to collect materials at short notice.

2.13 Customer Service

Philosophically, customer service signifies the logistics part that is satisfying the customer. A customer service programme must find out and organise all operations needed to achieve the customers' logistical prerequisites just as, or superior to, competitors. In fundamental customer service plans, the emphasis is normally on the operative part of logistics, guaranteeing that the firm has the ability and is capable of providing the seven 'rights' to its customers: "the right amount of the product, at the right time, at the right place, in the right condition, at the right price, with the right information" (Rushton, Croucher and Baker, 2006:167). Customer service includes various activities that make up customer-service elements (Fallah, 2011: 202).

2.13.1 Customer Needs

When a customer's needs are met this influences the company's revenue which, along with cost, decides the profitability of the delivery network. While customer needs consist of many components, those measures that are influenced by the structure of the distribution network include response time, product variety, product availability, customer experience, order visibility and returnability (Chopra, 2003:124).

2.13.2 Customer-Service Elements

According to Ballou (2004:223), customer-service elements can be categorised into three groups: Pre-transaction Elements, Transaction Elements and Post-Transaction Elements.

2.13.2.1 Pre-Transition Elements

Pre-transition essentials are not directly resolutely connected to logistics operations, but rather are further worried about administration and organisational matters and strategies (Christopher, 2005:166). These essentials produce a culture and environment that provides customers with a fulfilling customer-service network. Additionally, they possess the flexibility to react to a specific customer demand (Christopher, 2005:166). Furthermore, it is imperative to include customers within service processes so as to develop a decent and strong relationship with them (Ballou, 2004: 224).

2.13.2.2 Transaction Elements

Transaction essentials are directly associated with delivery and logistics processes. This category of essentials involves dealing with customer requests and meeting them on time and with high accuracy. Furnishing customers with on-time, arranged records such as the status of inventories and definite delivery dates creates a positive customer experience (Christopher, 2005:167; Rushton, Croucher and Baker, 2006 :144).

Order-cycle is a key component of the transaction process. Each phase ought to be engaged and managed in an efficient way. From the customers' perspective, order-cycle time is the duration of time from when they make an order, and when the material

or service is delivered to them (Fallah, 2011: 203). Order-processing operations are exceptionally reliant on how information flows between related departments.

2.13.2.3 Post-Transaction

Post-transaction essentials happen after the transaction and shipment of materials, and are applicable to the "consumption" of products (Rushton, Croucher and Baker, 2006: 14 6). The principal objective of these essentials is to give backup actions, such as managing customer grievances and entitlements. These support services include installation, warranty, alteration, repairs and availability of spares (Christopher, 2005:166). A customer may bring back delivered goods for some reasons, perhaps destruction sustained during conveyance, a request filling mistake made by the seller, or a mistake in ordering made by the customer. Therefore, every seller ought to have a plan to manage returns and should define a suitable way for handling them. Providing the customers with accurate and quick feedback is essential (Fallah, 2011: 204).

2.14 Customer Satisfaction

The customer's views about satisfaction and the goods producer's understanding of fulfilment are maybe alike at times, but they are usually not the same (Quesada, Gazo and Sanchez, 2012:41). The customer's satisfaction may be more on value to low cost, time taken for delivery, delivery date certainty or receiving a customised product. On the other hand, manufacturers and retailers are generally interested in realistic post-sales policies that would allow them to improve customer satisfaction levels (Kurata and Nam, 2010:137). In addition, a study conducted by Ou, Liu, Hung and Yen (2010:30) revealed that a well-managed, positive customer-firm-supplier relationship improved operational performance and customer satisfaction.

The inability to fulfil customers can emerge from the absence of understanding about customer desires, inappropriate standards of execution, performance failure, inefficient information flow, and from a discrepancy between the customer and firm's perception of performance. As customer expectation escalates, logistics managers should persistently screen customer fulfilment and logistics performance (Bowersox *et al.,* 2013:77).

2.15 The Influence of Construction Material Characteristics on Logistics

Chandler (2008:22) states that construction materials can be classified into various sets, based on how they are manufactured and, in the way that they can be handled on site. These classifications are:

i. Bulk materials - these are materials that are transported in an unpackaged state and are stored in a container.
ii. Bagged materials-these are materials transported in sacks for ease of handling and controlled use.
iii. Pallet materials-these are packed materials that are placed on pallets for transport.
iv. Packaged materials-these are materials that are bundled together to prevent destruction amid transportation and spoiling when they are stored.
v. Loose materials-these are materials that are partially produced and that must be handled individually.

The characteristics of materials determine the type of storage, handling, stowage, carriage and packaging that they require (Bowersox *et al*., 2013:221; Hannan, 2011:24; Michael, 2015:13). To avoid unusually low rates, transporters and warehouses frequently specify a minimum charge for the transportation and storage of light weight and weighty products (Rushton, Croucher and Baker, 2006:34). But, total delivery costs (including transportation and storage costs) tend to reduce as the volume-to-weight ratio reduces. Bowersox *et al.*, (2013:203) summarised five factors which influence transport cost as follows:

i. In-transit care necessitated by the intrinsic properties of goods.
ii. Density of goods as represented by their mass to volume ratio.
iii. Size and divisibility as determined by the physical dimensions of a consignment.
iv. Stowage ability and ease of handling as determined by the form of goods.
v. Potential liability of goods as determined by their value-to-mass ratio, fragility, susceptibility to theft and pilferage, and potentially hazardous characteristics.

2.15.1 Demand and Supply

Demand is mostly met from the inventory. This suggests the need to provide a safety stock level for the protection against demand variability or uncertain demand (Cronje, 2016:240). Several manufacturers keep closing their productions lines for holidays, machine maintenance and stock check. Thus, wholesalers and retailers need to increase stock holding preceding to the shutdown duration to safeguard that stock is available for their customers. However, this is not always the case. therefore creating a shortage of stock (Gwynne, 2014: 223). The supply chain can work better if a stock manufacturing strategy was applied. Stock levels should be maintained at a predetermined level. This should be supported by large production units, bulk purchasing, batch order processing and bulk shipment (Havenga and de Bod, 2016:46). Research by Ugochukwu, Ogbuagu and Okechukwu (2014:874) found that the potential total demand for cement in Nigeria is more than the supply, and was evaluated at 18 million tons. The assessed total utilisation rose by 8% to 14.8 million tons in 2009, and about 10.5% every year throughout the last six years. Similarly, the projected yearly per capita utilisation of steel in Nigeria is growing, exponentially extending from 5 kg in 1968 to 130 kg in 2012 (Uzondu, 2012:01). Regrettably, the rise in the demand of steel items has not been met by local production, even with the plentiful iron ore, coal and limestone deposits in the country (Ohimain, 2013:002). These statistics serve to justify the need for a study on Management-CMLS.

2.15.2 Ceramic Tiles

Tiles are frequently utilised to form wall and floor finishing's and can be of variety from ordinary glazed square tiles to complex mosaics (Ugochukwu, Ogbuagu and Okechukwu, 2014:876). Whether the industry is building housing` estates, institutions, clinics, factories and commercial or corporate buildings, ceramic products are extensively used. Ceramic products are the basic choice for both sanitary ware and finishes, and where cleanliness is of the essence. Since they are easily broken, ceramic products are delivered in a variety of packaging materials. The packing increases the volume of material that must be transported. Furthermore, ceramic materials are heavy materials by nature. When the quantity, volume and weight of ceramics in construction are taken as a whole, the logistical processes related to it become apparent, as well as significantly relevant to Management-CMLS (Shakantu, 2005:69).

2.15.3 Cement

Cement is the next most devoured construction material in the world after water. It is a unique protective and decoration material widely required in our daily life (Tarek , Bernd and Lima, 2013:03; Shukla and Sharma, 2015:109). Cement, as the most vital component of concrete and most mortars, is an important construction material and is used in infrastructure construction everywhere in the world. The cement devouring rate contributes to the financial development and growth index of several nations (Shukla and Sharma, 2015:111).

2.15.4 Blocks and Bricks

In most countries, individual family residences are mostly built using bricks or blocks (European Commission, 1999:74). When the quantity of individual dwellings is considered, the weight and volume of bricks and blocks required annually in any nation is substantial. The impact of this, from a logistics perspective, is therefore critical (Shakantu, 2005:69). The Management-CMLS must be continuously and consistently updated because of this vast impact on the economy of a country.

2.15.5 Crushed stones and Sand

Crushed stone utilised in a concrete mixture are selected either as fine or coarse. Fine aggregates range from 0.0254 to 6.3500 mm and coarse aggregates range from 6.3500 to 38.1000 mm (Pienaar, 2016a:438). Sands and in all respects finely crushed rocks are ordinarily utilised as fine aggregate. Coarse aggregate is most commonly gravelling or crushed rocks, such as limestone. These are unpacked materials with low value to weight ratios. The crushed granules are homogeneous loose/pelletized materials. They are classified as dry bulk materials which can be easily transported using tippers and trailers. These carry unpacked cargo with low value to weight ratios (Pienaar, 2016a:438).

2.15.6 Steel Reinforcement

Iron and steel are significant to the industrialisation and advancement of any nation. Iron and steel are needed in construction works, including for buildings, bridges, equipment, processing/ manufacturing plants, vehicles, household appliances, oil and gas infrastructure (Ohimain, 2013:002). The size and weight of the structural frame requires considerable logistics support. Regardless of whether it is in-situ or pre-cast

concrete utilised, the volume and weight of aggregates and reinforcement required to build reinforced concrete frames places significant impact on logistics systems (Shakantu, 2005:68).

2.16 Chapter Summary

The review of the related studies on the logistics systems, logistics concepts, elements (sub-systems) and the logistics functions present an idea of the critical need for logistics to be managed in a more efficient and effective way. The current logistics operations and processes within the logistics subsystems reveal that there is high inefficiency and ineffectiveness. The next section presents the theoretical and conceptual frameworks underpinning this research, with expansion on the concepts introduced in Chapter Two.

Chapter 3: The Theoretical and Conceptual Frameworks

3.1 Introduction

Chapter Two reviewed the major components of the logistics systems, their functions and interrelationships. This chapter discusses the crucial issues that guided how this research study was conducted. It introduces the core concepts of the study and the general framework for data collection and analysis. Theories, models and ideas are instruments used to reflect reality. As such, the application and utilisation of theories are important for better understanding of this kind of study. In this respect, the hypothetical structure introduces the theory that clarified why the problem featured in Section 1.3 of this study exists. This then leads to the development of the conceptual framework for the study. The theoretical framework of the research is described in Section 3.3, and the conceptual framework is presented in Section 3.4.

3.2 Introduction of Core Concepts

For this study, the management of construction material logistics systems is referred to as Management-CMLS. Concepts considered core to the issues of effective and efficient Management-CMLS need to be defined as they are derived from different sectors. The definitions of three such concepts follow.

3.2.1 Logistics Management

Logistics management is a discipline that traverses range limits within an organisation, thus guaranteeing the coordination of functions such as purchasing, production, inventory management, finance and marketing (Michael, 2015:11). In the more extensive network context, operational synchronisation is essential for customers as well as materials and services. This joins the internal and external operations into one integrated process.

3.2.2 Logistics Interfaces

Logistics is a crucial Supply Chain Management (SCM) element. Logistics supports organisations so that they achieve their objectives as efficiently as expected. In this regard, logistics utilises information collected from different functional sections of the

organisation (Cronje, Du Toit and Motlala, 2004:154). Logistics operations interface with manufacturing, operations and marketing as explained next.

3.2.2.1 Logistics in Manufacturing

The manufacturers logistics approaches were initially established mainly for their internal logistics, but with increasing outbound logistics processes the attention today is as much on the external logistics, and on the harmonisation between the members in the supply chain. The design is towards logistics 'pull' networks, where the item is pulled in reply to demand. This is contrary to being 'pushed' ahead in advance of demand (Shakantu, 2005:95). For Management-CMLS, the construction material manufacturers' and wholesale/ dealers' logistics are like the logistics of any manufacturers. However, if the contractors are not aware, their logistics too would be determined by the manufacturers and the dealers, who will minimise the cost of delivery to the construction site without considering the handling costs (Sven and Jorgen,1997:4).

3.2.2.2 Logistics Interfaces with Operations

Logistics ensures that the quantity of raw materials is enough to meet production strategies. Logistics transforms into a key empowering influence of operations through forward arrangements of, for example, Material Production Schedules (MPS). An additional role of logistics in operations management is in the choice of packaging (Rushton, Croucher and Baker, 2006:144; Langley, Coyle, Gibson, Novack and Edward, 2009:47)

3.2.2.3 Logistics Interfaces with Marketing

Manufacturing companies need to enhance marketing capacity to meet the logistics requirements of the market and improve the competitiveness (Kim, 2013:74). The logistics system manages the physical transportation and storage of materials for customers and accordingly plays a vital role in selling a product. Additionally, it is responsible for the marketing of the products. Logistics turns out to be especially noteworthy in timing the responsiveness to demand inconsistency created through the promotion of activities and other sales improvement exercises (Shakantu, 2005:95).

3.2.3 Construction Supply Chain Integration

Construction supply chain management has introduced some new methods to reduce cost and increase the dependability and promptness of construction projects. Dainty, Briscoe and Millett (2001:163) defined supply chain management as the managing of a network of firms which are involved in undertaking a business. In the construction industry, these networks can be of a mind-boggling nature in perspective of the significant figure of distinct companies engaged on a large project.

There are two main World views inside Supply Chain Management Theory in the construction industry. The first, is related to Logistics Theory, aiming at reduction of waste through effective management of delivery of materials to a construction site (Khalfan, Kashyap, Li and Abbott, 2010:210). This perspective focuses on the logistics of the construction process. It influences builders merchants to interface as groups of subcontractors focusing on the main contractor. Bertelsen (1997:122) observed the construction supply chain from a logistics perspective. He noted that a considerable rise in efficiency could be achieved by transporting and handling building materials efficiently, depending on situations present on a project site.

The second World view is related to LEAN Reasoning and tries to find value across the whole chain of supply (London, Kenley and Agapiou, 1998: 369). In contrast, this supply chain management World view is focused on comprehension and enhancement of the harmonisation of numerous firms that form a supply chain (O'Brien, London and Vrijhoef, 2002:129). Figure 3.1 presents a theoretical perspective of a construction supply chain. However, this chart does not give an illustration of the complexity of supply chain production processes.

The supply chain in the construction sector can be regarded as a series of actions that change raw materials into finished products. Different to other manufacturing sectors, the construction industry comprises of three separate but co-dependent supply chains, namely professional services, building and assembly, and materials supply (Cox and Thompson, 1998:77). The construction industry encounters solid blockades to supply chain incorporation because of the long established unfavourable contractual nature of relationships in construction projects, as well as the fragmented production environment (Li, Qiming, Wenxian and Wenxiong, 2007:22). This difficulty results in

inefficient, ineffective and inadequate techniques to distribute good service and profitability (Khalfan *et al.*, 2010: 211). This forms the crux of Management-CLMS.

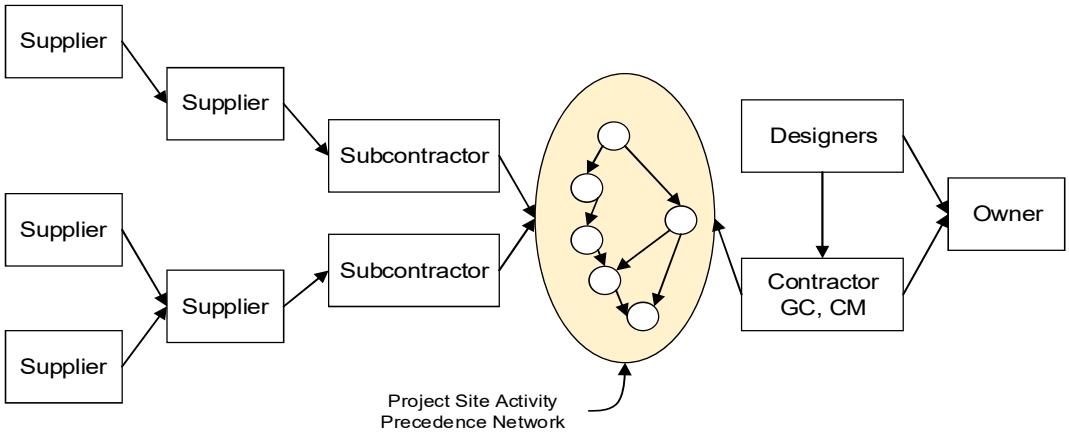

Figure 3.1: Conceptual View of the Construction Project Supply Chain
Source: O'Brien, London and Vrijhoef, (2002:129)

3.3 Positioning of the Theoretical Framework

The issues of logistics of construction material delivery and information flow fall into three seemingly divergent areas of logistics management within the main areas of systems, effectiveness and efficiency of the supply chain. It is imperative to note that logistics systems have the dual aim of efficiency and effectiveness. The former refers to the minimisation of total logistics costs (of materials and information), while the latter refers to maximisation of final customer satisfaction. However, these two conflicting objectives need to be balanced in a strategic way (Elena and Giacomo, 2001: 4).

These important ideals of effectiveness and efficiency fall within the main area of SCM. Any improvement in SCM would have at its core an efficiently working logistics system (minimising the use of resources). Similarly, an effective logistics system would not be achieved if the manufacturers operated wastefully, dangerously and expensively (Shakantu, 2005:168). The problem to be resolved is how to minimise resources and costs in the construction logistics system, whilst retaining the same level of construction output.

This research study focuses on the intersection of logistics systems, effectiveness and efficiency. The issues are approached from a manufacturing perspective and are presented through some relevant construction illustrations.

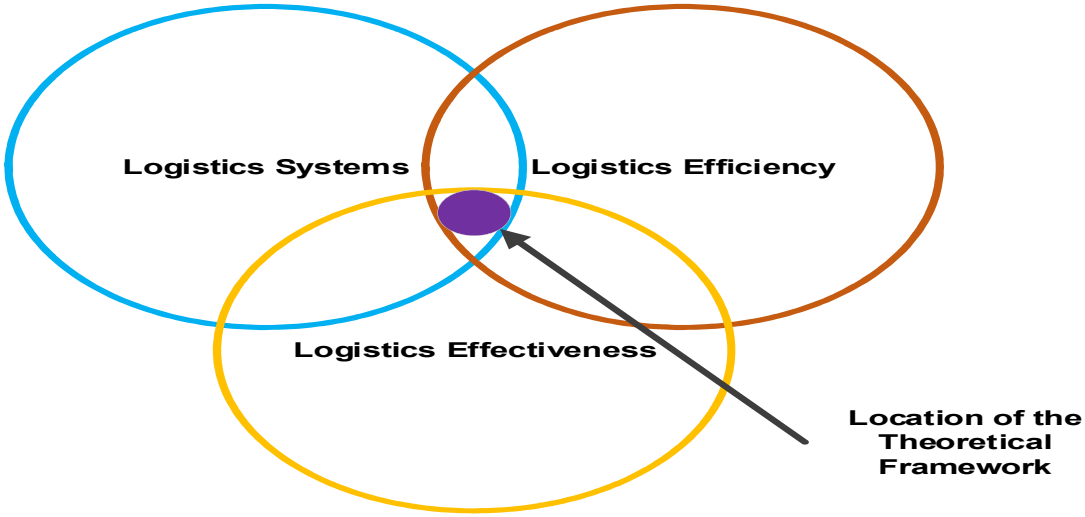

Figure 3.2: Illustration of the Positioning of the Theoretical Framework
Source: Researcher's Construct (2019)

3.3.1 The System Concept

Refer to Figure 2.1 in Section 2.2.4 of the thesis for identification of logistics systems. The objective of systems investigation procedure is to make the entire or integrated effort, one which is better than the total of the individual parts or functions. Such incorporation produces a combined power of working together that is greater than the power achieved by working separately (Bowersox *et al.*, 2013: 291). Adebumiti *et al.*, (2014; 244) describe a system as a group of interconnected companies (also called sub-systems) all collaborating to form a network. They operate simultaneously to guarantee an effective operation of the system. The sub-systems are vital to the point that should any of them fail, the whole system would be affected and result in an overall system failure.

In another vein, Alter (2010:14) defines a system as that where human members and/or equipment perform operations by means of information, technology and other resources to produce products and provide services to internal and external customers. Network optimisation enables competitiveness, and achieving of a synergy effect which comes from the Theory of Systems (Zhou, 2013:134). The system also needs to be able to interface with automation systems, conveyors, WMS, RFID and pick-and put-to-light systems (Gwynne,2014:195). The best systems monitor the procedure as well, not only just the stock. This implies that monitoring and evaluation

takes place after each activity has happened, thus showing mistakes instantly. If mistakes are removed, the idea of a periodic stock check becomes unnecessary.

3.3.2 Concepts of Effectiveness and Efficiency of Logistics Systems

Efficiency is an evaluation of the manner that the utilisation of assets maximise output, given the effort and technology. It is the evaluation of the way the allotment of inputs minimises the cost to satisfy given objectives. ‘‘Efficiency by and large suggests realising an objective at the most minimal.” while on the other hand, “effectiveness is evaluation of how well service conforms to the expectation of customers or how well goods satisfy their needs cost’’ (Pienaar and Havenga, 2016b:22). As a performance measure, effectiveness may be expressed as the degree to which the desired level of service is provided to meet stated goals and objectives. Schneider and Leslie, (2015:22) summarised the definitions of these concepts as indicated in Table 3.1.

Table 3.1: Definitions of Effectiveness and Efficiency

	Increases Efficiency	Improves Effectiveness
Definition	Allows organisations to do the same amount of work with fewer resources	Allows organisations to generate higher revenues, independent of resources required
Examples	Automation of manual process Organisational restructuring/outsourcing	Expansion of online presence Increased insight into customer behaviour/preferences

Source: Schneider and Leslie, (2015:22)

The significance and complexity of logistics performance evaluation prompted the construction of various performance evaluation frameworks and models (Brewer and Speh, 2000:75; Griffis, Cooper, Goldsby and Closs, 2004:95). One such model, developed by Fugate, Mentzer and Stank (2010:52), mirrors the interdependence of logistics efficiency and effectiveness, and differentiation within logistics performance and overall organisational performance. This model and perspective of logistics performance is upheld by numerous other researchers who concur that logistics performance is a multidimensional function of efficiency, effectiveness, and differentiation (Bobbitt, 2004:157) and that all can and ought to be "pursued simultaneously at the same time" (Fugate, Mentzer and Stank, 2010:52).

However, logistics decisions are made bearing in mind the different levels of optimality, and the outcome may be a few levels being sub-optimised to the detriment of other levels. Basic to logistics decisions is the ability to understand all of the other components affected, and afterward optimise at the required level (Langley *et al.,* 2009:68). In summary, supply chain efficiency and effectiveness are interdependent standards that measure a quasi-organisation (Bandow, Wötzel and Man, 2013:4).

3.4 The Conceptual Framework of the Research Study

A conceptual framework in research shows the researcher's lens being used to view the research problem, or to take a position on it. This then gives direction to the study, and further shows the relationships that exist between the different constructs that the study intends to evaluate (Adebumiti *et al.,*2014; 237). The literature review revealed that there is ineffectiveness and inefficiency in the operational performance of Management-CLMS. Refer to Sections 2.8, 2.9.3, 2.10.5 and 2.11.5.

Fundamentally, it is accepted that any inefficiency in the delivery of construction materials leads to a rise in material costs and, thus, a rise in construction costs (Vidalakis and Sommerville, 2013:479). Moreover, optimisation of operations in separate subsystems does not guarantee overall optimisation, and this has been the motivation behind why researchers have changed focus to a more integrated approach. Two issues, profitability and a prompt response to market changes, can explain the motive behind implementation of effective and efficient integrated logistics optimisation models (Behnam, Reza, and Mohammad, 2011:373). Furthermore, there is a need for total collaboration between parties in the supply chain operations system that would find an equilibrium between two conflicts: objectives of effectiveness (maximisation of customer satisfaction) and efficiency (minimisation of use of resources) (Sardana, 2009:40).

Therefore, the identification of a proper technique for coordinating the current performance measures into the holistic, integrated framework to assess the supply chain is essential (Prasad, 2012: 47; Bandow, Wötzel and Man, 2013:4). The problem facing this identification was understanding how effective and efficient Management-CMLS can be used by manufacturers to achieve customer satisfaction, while still maintaining their profit. The concepts emanating from the theoretical aspects of

logistics management contribute to this understanding and are central to this study. Figure 3.3 illustrates the positioning of the conceptual framework to guide the evaluation of the operational performance of Nigeria's manufacturers as they relate to Management-CMLS. Therefore, this research is focused on the intersection of enablers under system, effectiveness and efficiency. Figure 3.3 illustrates what effective and efficient Management-CMLS would look like.

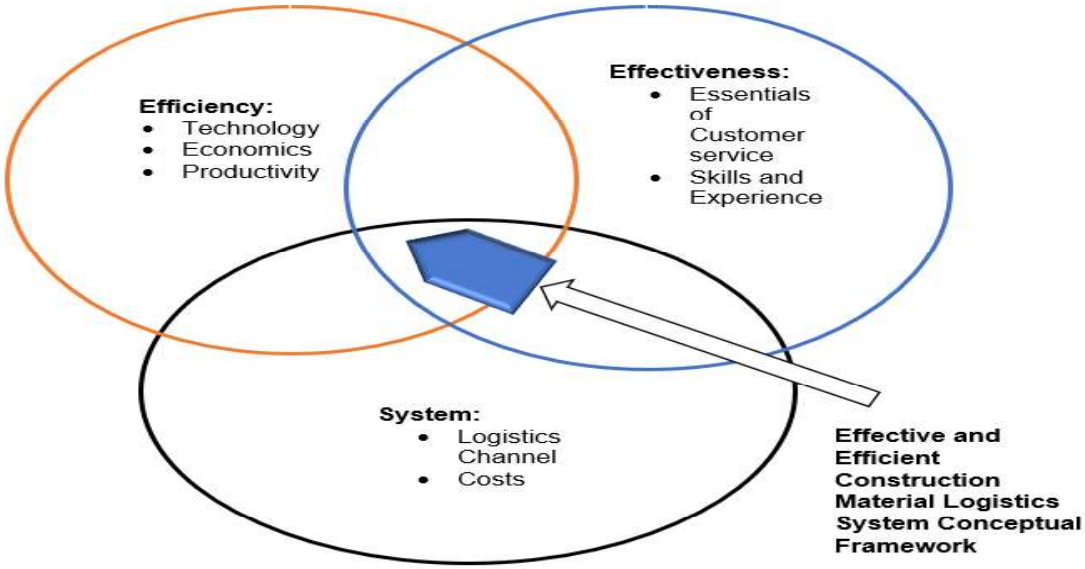

Figure 3.3: Effective and Efficient Construction Materials Logistics Management
Source: Researcher's Construct (2019)

3.5 Logistics Channels and Cost

Logistics channels were identified, and their functions and objectives discussed in Section 2.12 of this study. The efficiency and effectiveness of logistics channels, logistics costs and the analysis of construction materials logistics costs also contribute to efficiency and effectiveness.

3.5.1 Efficiency and Effectiveness of Logistics Channels

Many logistics procedures are conducted through logistics channels. Delivery of products is conditioned by the efficiency of logistics procedures. For an efficient and effective logistics system, the goal of the delivery network is to select the optimum numbers, locations and capacities of plants and warehouses such that all customer demand is satisfied at minimal overall cost to the outbound network (Turkensteen and

Klose, 2012:499, Andrejić and Kilibarda, 2016:137). Minimisation of delivery distance-related costs can be achieved by the proximate location of warehouses and distribution centres (Turkensteen and Klose, 2012:499).

Essential competitive features are "reducing lead times, delays, and whole transportation costs, as well as improving efficiency, reliability and quality'' in administration of the systems (Hoff *et al.*, 2010:2058). However, it is worth noting that the cost of material may rise due to the presence of intermediaries in the material delivery process. From a broader perspective, compared to manufacturers, intermediaries do profit users by reducing the transportation unit cost (Khooban, 2011:111).

Michel (2007:76) defines channel performance by results gained from various dimensions, which he used to evaluate the effectiveness of outbound logistics channels. The dimensions are:

i. Effectiveness: How well did a channel respond to the customers' requirements and expectations?
ii. Efficiency: How well did a company minimise costs related to this channel's operations?
iii. Productivity: What was the rate of return of the channel?
iv. Profitability: What was the economic performance of this channel?

A study by Khalfan *et al*. (2008: 358) concluded that there was potential to use the know-how and understanding of a manufacturer's logistics channel at the start of a project to accomplish effective planning and delivery of the whole project. This would enable greater supply chain collaboration. Chopra (2003:140) summarised that intermediaries like wholesalers and distributors add value to a logistics system, especially between the supply and customer stage. If there are numerous small players at the customer stage, with each demanding a small quantity of the material at a time, then movement is faster. Improvement in logistics system performance occurs.

3.5.2 Components of Logistics Costs

Figure 3.4 shows the components of logistics costs (Chang, 1998:124). The figure demonstrates that transportation is the most remarkable cost, taking up 29.4% of all logistics costs. It is trailed by expenses for the inventory, warehousing, packaging, management, movement and ordering. This figure connotes not just the cost structure of a logistics system, but also grades the sequence of significance in improvement processing (Kavran, Jolic and Cavar, 2009 :336). It reflects an important ratio in logistics activities. Cutting down the items which charge higher operation costs can result in even better effects.

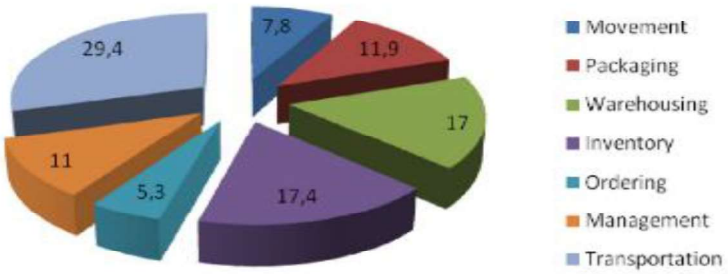

Figure 3.4: Cost Ratio of Logistics Items
Source: Kavran, Jolic and Cavar (2009 :336)

3.5.3 Construction Material Logistics Cost

The core construction logistics operation that helps in material delivery from the point of manufacturing to the construction site was reviewed by Lin, Collin and Su (2001:30). The Total Acquisition Cost (TAC) of material is the sum of all the reliability and potential costs associated with the purchasing process (Department of Trade and Industry, 1995:76). It combines all direct and indirect costs related to the buying of a product or service through the entire supply chain, including the purchase price.

Poor cost performance by manufacturers and suppliers can significantly increase the TAC of construction material which, through rising material purchase prices, results in higher construction costs (Vidalakis and Sommerville, 2013:473). An investigation by Wegelius-Lehtonen (1995:209) discovered that a material merchant's logistics cost is in the range of 2% and 18% of the material buying price, confirming that construction budgets can be significantly influenced by the unintended costs linked to outbound logistics efficiency. In addition, Scandinavian-based research by Soderman

(1985:124), revealed that up to 40% of material expenses can be ascribed to costs identified with logistics operations.

3.6 Efficiency and Effectiveness of Transport Systems

Andrejić, Bojović and Kilibarda (2016:99) recognised two factors in their evaluation of the efficiency of transport systems. The first factor was fleet efficiency, which is focused on senior level decision making. The second factor is vehicle efficiency at the operational level of decision making. The effects of efficiency and economy of transport follow.

3.6.1 Efficiency and Economy of Transport

The efficiency and economy with which input is planned to attain a set of objectives has a direct effect on the competitiveness of a business. Economy is the minimal utilisation of resources with the goal that greatest advantage is achieved from any given output. Economies of scale in transport are reliant on the accomplishment of any or all the three sub-classes of economies. These are economies of density, economies of scope and economies of distance. The degree to which any of these economies might be realised within each transport mode is determined to a great extent by its physical characteristics and cost structure (Pienaar, 2016c:390). The way to accomplishing economical transportation is summarised by two fundamental standards. The first, frequently identified as the Quantity Principle, is that a single delivery ought to be as substantial as the participating transporter can lawfully transport in the vehicle being used. The second, regularly called the Tapering Principle, is that big deliveries should be transported over long distances if possible (Bowersox *et al.,* 2013:295). Road transport efficiency follows.

3.6.2 Road Transport Efficiency

Understanding of transportation economics and pricing is fundamental for efficient logistics management. The essential components of transportation costs are distance, volume, handling, liability and market factors. These control transportation prices, which are included in the budget as rates for performing specific services (Bowersox *et al.*, 2013: 203). Pienaar (2016c:388) identified the key factors of road transport efficiency at cost level, the economies of fleet size, economies of vehicle size,

economies of infrastructure extension and economies of distance. These important factors should also be evaluated from a manufacturer's perspective.

3.6.2.1 Transport Cost

The cost to deliver a unit of cargo by air is the most expensive of all means of transport. Road transport is the second most expensive when on long distance haulage, and third on short journeys where road is cheaper than rail transport. In the meantime, rail transport achieves significantly more economies of distance than road transport. Road transport becomes increasingly more expensive than rail transport for all classes of freight as trip distance increases above approximately 500km (Pienaar, 2016c:390). For trips of about 150km, road transport is effectively cheaper than rail transport. Either rail or road transport is the cheapest mode for all those commodities that cannot be carried by pipeline. The total unit cost to carry freight by sea on voyages longer than 300km is the lowest of all modes of transport (Pienaar, 2016c:390).

3.6.2.2 Economies of Fleet Size

Fleet efficiency is determined at the administrative level of decision making. Transport managers use information on the total distance of shipment and quantity of material delivered in tonnes (Andrejić, Bojović and Kilibarda, 2013:100). The evaluation of the company administration, fleet size, gravity region (catchment zone, the region that DC /WH serves,) the age of the vehicle, vehicle capacity, vehicle producer, all impact the efficiency status. These basics are not adequately investigated in the literature (Cruijssen, Dullaert and Joro, 2010:166; Andrejić, Bojović and Kilibarda, 2016;100).

In-house facilities, for example, terminals specifically created for dedicated transporters, offer opportunities for economies of scale. Probable bases of economies of scale would be a workshop owned by the company for vehicle maintenance and repairs, standardised vehicles that reduce the quantity of spare-part inventories, discounts on bulk purchases and so on. Improved road vehicle fleet sizes, combined with productive utilisation of this capacity, can result in some economies of scale (Pienaar, 2016c: 388)

In summary, Pienaar (2016b:419) outlined nine principles that act as guidelines for promoting efficient freight transport operations:

i. Continuous flow;
ii. Maximum unit load size;
iii. Maximum vehicle size;
iv. Maximum mass-carrying capacity in relation to total vehicle mass;
v. Adaptation of vehicle unit to volume and nature of traffic;
vi. Standardisation;
vii. Long-haul freight consolidation;
viii. Maximum utilisation of input; and,
ix. Compatible unit load equipment.

3.6.2.3 Vehicle Total Capacity

Transport efficiency is accomplished by Full Truck Loads (FTL) and utilising the transport for as long as possible each day. However, delivery consolidation is linked to the capacity of the firm to achieve a greater number of orders while performing fewer vehicle movements. Therefore, it is determined by the relationship between the number of deliveries satisfied through a single vehicle shipment and the related shipped distance (Vidalakis and Sommerville, 2013:478).

The size of a truck influences other vehicle indicators, such as fuel consumption and the shipped tonnes (Kim, 2010:89). Most importantly, the economies of vehicle size are achieved as the carrying capacity of vehicles increases; vehicle-specific costs increase less than proportionally. These are running costs, such as fuel and oil consumption and vehicle maintenance. Additionally, engine size and the number of persons required in the driving crew increases with vehicle size. The cost of delivery and load invoicing have the tendency to remain the same regardless of load or shipment size (Pienaar, 2016c: 388).

3.6.2.4 Economies of Distance

Economies of distance, otherwise called long-haul economies, are achieved when the total transport cost per ton-kilometre reduces as the trip distance increases. Economies of distance emerge “when there are trip-specific fixed costs that are not influenced by the distance of the journey, and by cost items that increase less than proportionally to an increase of distance” (Pienaar, 2016c:381). Generally, due to the high costs of running a vehicle (which accumulates as distance increases) compared

with the complete cost of a sole vehicle, and the moderately little terminal facilities or lack of provision of individual facilities, road transport does not enjoy significant economies of distance. In fact, it is the second lowest of all modes of transport, with pipeline transport being the lowest (Bowersox *et al*., 2013: 295; Pienaar, 2016c:390).

3.6.2.5 Economies of Weight and Density

Like other logistics processes, scale economies exist for most transportation movements. This relationship shows that delivery cost per unit of weight decreases as load size increases. In order to improve economies of density, Pienaar (2016c:380) suggested the following strategies:

i. Using high-capacity technology to carry and handle bulk loads;
ii. Minimising loading and offloading times;
iii. Utilising traffic consolidation (load, trip, route and loading point consolidation); and,
iv. Maximising the immediate and continuous utilisation of vehicles (immediate utilisation refers to the measure where the carrying capacity of vehicles is fully utilised, while continuous utilisation refers to the number of revenue-kilometre or revenue trips covered per period).

The Federal Highway Administration Reports (2011:44) observed that the expenses of products delivered is anticipated to rise quicker than the weight, increasing from $890 per ton in 2007 to $2,145 per ton in 2040, based on monitoring the price increases. As such, dealing in lighter-weight, higher-value products would exceed bulk commodity categories (Broks, 2005: 22).

3.6.3 Dwell Time and Idling

Vehicles are not dispatched to their various destination locations except when they are fully loaded or offloaded respectively. For this reason, a vehicle waits until when it is either fully loaded or offloaded. The whole of the load waiting time, the time wasted because of overcrowding and other issues make up the total waiting time, or Dwell Time (DT) of a Vehicle. The vehicle may wait at a plant, DC/WHS and a retailer's store before it is sent to the next destination (Eskigun, Uzsoy, Preckel, Beaujon, Krishnan and Tew, 2005:185). Furthermore, there might be some idling time because of managerial problems or ineffectiveness in the system. This may be unrelated to the

volume of construction vehicles passing through these destinations (Eskigun *et al.,* 2005:185; Gwynne, 2014:73).

Without proper scheduling of vehicle delivery, the workload in the facility will vary excessively. The burden on the operating staff increases during peak times and this reduces efficiency and the accuracy of the receipt (Vogt, 2016b:334). Long-distance trucks can remain idle for between six to sixteen hours per day (Grupp, Forrest, Mader, Brodrick, Miller and Dwyer, 2004: 237; Rahman, Masjuki, Kalam, Abedin, Sanjid and Sajjad, 2013: 171).

Throughout rest times at vehicle stops, or while loading and offloading at customer locations, drivers tend to keep their vehicle engine running with a specific end goal, namely to keep up their comfort level, ensuing from the use of air conditioners, heaters, televisions, refrigerators and lights. Engine idling is the main challenge in long distance transportation since it increases fuel consumption, as well as emissions of NOx, PM, CO_2, CO, and hydrocarbons (Argonne National Laboratory, 2015:2).

3.6.4 Vehicle Shipping Efficiency

According to Vidalakis and Sommerville (2013:273), to gain understanding of complete vehicle utilisation, three indicators are proposed: Vehicle Shipping Efficiency (VSE), Vehicle Journey Efficiency (VJE) and Vehicle Weighted Efficiency (VWE).

VSE is the underlying loading state of the vehicle, without considering any vehicle shipment features. It is valuable since it is a key determinant of the vehicle dispatch criterion. Certainly, taking into consideration a most extreme lead time that an organisation will in general achieve, vehicles with high VSE are more likely to be dispatched than vehicles with low VSE (Vidalakis and Sommerville, 2013:473). VSE can be calculated using the following formula: VSE = ADo ÷ PDo × 100 (1), where ADo is a vehicle's actual overall delivery and PDo is a vehicle's potential overall delivery.

VJE, as the term suggests, studies loading efficiency through individual journeys between two successive delivery locations. In correlation with VSE, VJE gives a full understanding of the vehicle loading condition throughout the vehicle delivery. VSE

is combined in VJE computations, signifying vehicle efficiency throughout the first journey starting from the manufacturers warehouse.

"To calculate VJE, the formula is: VJEn = ADn ÷ PDo × 100 (2), where ADn is a vehicle's actual delivery at location n; PDo is a vehicle's potential overall delivery; and n =,1, 2,....., is the number of deliveries per movement" (Vidalakis and Sommerville, 2013:473).

VWE, similarly to VJE, depends on vehicle efficiency throughout individual journeys. But, VWE is weighted by the length of the journey leg in connection to the entire length of the related vehicle drive. VWE is computed using the equation: VWEn = $\sum(VJEn\ x\ JDn) \div TD$. (3) "where VJEn is vehicle journey efficiency; JDn is the distance between locations n – 1 and n; and TD is the total length of vehicle movement" (Vidalakis and Sommerville, 2013:473).

Research by Vogt (2016b: 342) for a survey of eight UK companies specialising in vehicle logistics revealed that VSE calculated was approximately 95% in the outbound stage of the delivery. However, a similar study by Vidalakis and Sommerville (2013: 273) found that the average VSEs calculated for the Builders Merchants (BM) and the Material Suppliers (MS) were 24.1% and 39.4% respectively. This was definite because of the low VSE values and largely connected with the frequency of empty runs taking place during reverse journeys, which was established by the very low collections/transports ratio.

3.6.5 Technology in Transportation

An Intelligent Transportation System (ITS a), incorporates Information Technology Communications (wireless) and Geographic Information Systems (GIS) based software into roads, trucks, traffic and transport management systems. ITS guarantees more up-to-date transport managers, customers and prompt response services, in this way improving safety, fairness, efficiency and ecological protection (Kavran, Jolic and Cavar, 2009: 335). Software for Transport Management Systems (TMS) allows for effective and efficient management of the transportation fleet used in the outbound logistics system (Andrejić and Kilibarda, 2016:143). TMS make it possible to assess

driver performance and vehicle efficiency by remotely monitoring speed, braking, gear-shifting, idle time and out-of-route miles (Ruamsook and Thomchick, 2012:135).

TMS helps drivers to reduce the probabilities of getting lost, monitors pickup and transport schedules, and confirms bad weather and traffic congestion. The results are a reduction in uneconomical idling at loading bays and in traffic, and a decrease in the distance driven, all of which leads to fuel saving and emission reduction (Wright, 2010:31; Biederman, 2011:78). An investigation into load shipment organisations by Ndonye (2014:2) advocated that they should utilise information technology to enhance the efficiency and effectiveness of their logistics performance in a bid to achieve a competitive advantage. Andrejić and Kilibarda (2016:143) recommend that it is important to integrate TMS, WMS and other systems.

3.7 Efficiency and Effectiveness in Warehousing

This section presents an overview of efficient warehouse layout, location, size and space utilisation. It includes the network structure of warehouses, efficiency of warehouse operations, effectiveness in the warehouse, LEAN warehousing, loading and offloading in the warehouses.

3.7.1 Warehouse Layout

An efficient warehouse layout ought to reduce the total amount of movement and handling points. It needs to prevent bottlenecks and cross traffic where feasible and ensure that movement takes place in a logical sequence. The complete cube of the building should be utilised and not just the floor space. The warehouse process depends on suitable floor area both inside and outside the dock bays. Attainment of the correct equilibrium between the number of entrances, equipment and labour is hard to attain and needs the harmonization of arrivals and departures with existing resources. A traffic jammed loading area can result in arrival and departure delay, loss or misplaced products incorrect dispatches and damage to items (Gwynne, 2014:73; Vishnu, 2016:166).

The facility must also control operations within the building and the interaction with transport vehicles (Vogt, 2016b:333). Again, as in many other warehouse areas, design is all about trade-offs between “speed, travel distance, space utilisation,

handling, access safety, risk and cost" (Gwynne, 2014:74). The Chartered Institute of Logistics and Transport has published on this subject and provides a step by step guide to warehouse design (Baker and Perotti, 2008:20).

3.7.2 Location, Size and Space Utilisation in Warehouses

In addition to transportation costs, DC/WH location is based on availability of main markets and customers. The point where the DC/WH is situated, for example, near several demand points or retailers, establishes point scale economies. Steady demand is then easier to accomplish (Ecklund, 2010:14). Meanwhile, various retailers require diverse kinds of locations; a completely maximised place for one store may be a failure for others (Afshari and Benam, 2011: 276). From a micro point of view, logistics effectiveness relies upon the time and distance relationships between the nodes of the system, such as MS and BM proximity to construction sites (Vidalakis,Tookey and Sommerville, 2011:73).

The size of DC/WH is the topic of a current debate concerning whether organisations are going to increase size or reduce the number of DC/WHs used within the supply chain (Gwynne, 2014:20). An investigation by Motorola, (2013:14) demonstrated that 35% of the respondents intended to increase the number of warehouses, whereas 36% hoped to increase the size of their current DC/WHs. Costs are higher if multiple DC/WHs are selected, but these costs can be off-set by a substantial reduction in local transportation cost and improved service (Gwynne, 2014:20). Moreover, to fulfil the sophisticated distribution functions for customers, new warehouses are made bigger. Even 92903.04 square metres is now a common size (Hoover's INC Company, 2014:2). On the other hand, Milan (2013: 98) advised that it does not make a difference whether a DC or WH is 1000 square meters or 500 000 square metres. Instead, it is critical to reduce costs and to increase operating efficiency. But there is necessity for a trade-off between number and size of the DC/WHs and retailer store spaces. The size of DC/WHs in the supply chain will also affect the transport arrangements (Michael, 2015:16).

Warehouse space utilisation is usually evaluated on the total floor space that is utilised. Nevertheless, it is more realistic to measure the cubic utilisation of the building. Other companies would look at the number of pallet locations utilised against

the total number of locations available (Gwynne, 2014:295). The cost of walls is not a significant fraction of the overall building cost. However, the floor and roof are estimated to be about 80 percent of the total building cost. Consequently, it is essentially more economical to increase storage space vertically than to make extra floor area. Storage in racks is a very profitable means of increasing the volume of goods in each floor space (Vogt, 2016a:264). The trade-off here is cubic utilisation versus potentially slower retrieval times. The warehouse height of 15m creates double volume to allow for optimal aisle width for a fork lift truck and cube-method space utilisation (Gwynne, 2014: 74). The floor and cubical space should be effectively utilised through adequate racking (Ramaa, Subramanya and Rangaswamy, 2012:15). Thus, there is a need for space trade-off between the floor and cube-method of space utilisation.

3.7.3 Network Structures used for Warehousing

Warehousing exists to support marketing, manufacturing and logistics efficiency, while the job of the warehouse has conventionally been to stock inventory. Modern warehousing includes a more extensive offering as far as economies and service benefits are concerned. Economic benefits comprise consolidation and break-bulk, sorting, seasonal storage, and reverse logistics. Service benefits include spot-stocking, full line stocking and value-added services (Bowersox *et al*., 2013:226). Four main factors describe warehouses: consolidation, breakbulk, mixed and cross-docking.

3.7.3.1 Consolidation Warehouses

In a consolidation warehouse, finished products sourced from different companies are transported in LTL deliveries to the warehouse. The consolidation warehouse is usually located near the manufacturing companies, so the cost of the LTL deliveries is kept to a minimum. Thereafter, the products are transported in bulk by FTL deliveries from the consolidation warehouse to the ultimate destination, which is usually located far away. The consolidation warehouse thus helps in consolidating several small LTL shipments into a single or a few FTL shipments (Ballou, 1999:144).

3.7.3.2 Break-bulk Warehouses

A break-bulk warehouse is the opposite of a consolidation warehouse. The bulk delivery, received normally in FTL quantity from a distant manufacturing company, is broken into smaller loads at the break-bulk warehouse. These products are then sent as LTL deliveries to smaller retail outlets or to customers located nearby (Ballou, 1999:144).

3.7.3.3 Mixed Warehouses

In a mixed warehouse, products delivered from several manufacturers arrive as FTL consignments to the warehouse. Deliveries are separated and afterward combined again to create several multi-product FTL shipments. Each of these multi-product FTL or LTL deliveries goes as a direct delivery to one of the several retailers/customers. A mixed warehouse thus combines the approaches of both consolidation and break-bulk warehouses. Transportation economies can be obtained by using a warehouse as a consolidation point and a break-bulk centre (Ballou, 1999:144; Bowersox *et al.*, 2013:226)

3.7.3.4 Cross Docking Warehouses

Cross docking implies that products from a dealer or producing company are transported directly to a customer or retail chain with little to no handling or storage. It explains the process of offloading products from an inbound vehicle and then moving them across the terminal to the outbound vehicle. This removes processes that add no value, such as put away, storage and order filling. The time taken for the operations called 'cross docking' is a debatable point. Practically, there may be some delay and the material may stay in the DC/WH for between 1 to 3 days. The complete process is done under 24 hours in a normal cross dock (Rouhollahi, 2011:44).

3.7.4 Efficiency of Warehouse Processes and Procedures

Efficiency largely suggests accomplishing an objective at minimal cost (Pienaar and Havenga, 2016b:22). Three criteria underpin efficient processing at any warehouse facility. These mirror the criteria against which all processes must be evaluated for efficiency (Vogt, 2016b:333). These criteria are as follows:

i. Products or merchandise just lying within the limits of facility, outside a chosen storage zone, mirror a wasteful process. Whatever space where products are at rest for instance, in the receiving area are indications of efficiency.
ii. The position of merchandise inside the limit of the warehouse must be known to guarantee effective operation. If not, the goods may not be accessible for efficient delivery, or issues may emerge with the receipt of extra products.
iii. People will do their task productively just if they are skilled to carrying out the job in the most ideal manner and are given enough opportunity to do the job without mistake. Time and effort are required to rectify errors. Proper, formal training is the best way of preventing errors.

Warehouse efficiency is vital to adequately handle a supply chain and attaining the best in class performance. Technology is an empowering influence in this regard (Gwynne, 2014:202). Practically all quality enhancement emanates from streamlining processes and procedure. These operations should be united and working optimally to improve efficiency and subsequently, reduce cost inside the warehouse operations. These processes include pre-receipt, receiving, put-away, storage, picking, replenishment, value-adding services and despatch (Bowersox *et al.,* 2013:231; Gwynne, 2014:58). Comprehensive process pamphlets need to be printed and given to all employees. They also need to be continually reviewed and updated. The Warehouse Education Research Council (WERC) (2010: 122) states that firms which display good to best practice outline and publish process descriptions, and delegate process responsibility to an individual. Adding guiding principles with photographs also enhances understanding. In the next section these processes are examined in relation to warehouse operations.

3.7.4.1 Receiving and Put-away

The receiving process is critical to the efficient and effective process of the warehouse. Warehouse administration plans and controls optimise the products flow and the use of resources in a warehouse, with the objective of minimising operational costs by removing wasteful work and inefficient movement of people and equipment (Poon, Choy, Harry . Chow , Henry, Lau, Felix and Chan, 2009:8277; Vishnu, 2016:162). Gwynne (2014:76) identified the following steps to be considered to improve productivity in the receiving and put-away area:

i. Ensure that you have booked arrival slots for most of your suppliers;
ii. Reduce the amount of checking required on inbound deliveries;
iii. Have a system in place to prioritise inbound goods, for instance, prioritise low stock items and promotional items;
iv. Plan your put-away meticulously and ensure products can be located accurately and efficiently; and,
v. Cross check as much as possible.

3.7.4.2 Picking Strategies and Equipment

This is where progress in technology has transformed the picking process and improved accuracy and productivity. WERC (2012:22), in a benchmark study, used the key performance measures to distinguish best-in-class picking processes. Figure 3.5 demonstrates the inter-relationship between labour, technology, equipment and warehouse layout. There are several interconnected choices that should be made and companies linked to be effective in this area (Gwynne, 2014:78). According to the Aberdeen Group (2009: 22), 46% of best-in-class companies are using cutting-edge pick methods such as batch zone and cluster picking, as opposed to individual order picks. However, each firm has diverse conditions and these approaches may not suit everyone.

There are different picking strategies that can be used inside a warehouse. These will rely upon the type of product, the velocity of through put and the company's budget. Picker-to-goods strategies remain the most used technique inside current warehousing processes. But, goods-to-picker operations are making strides as automation turns out be increasingly complex and gradually affordable. It is conceivable that different procedures will be utilised in the present warehouses as they hope to adapt to multichannel outbound requirements. The strategies and equipment guidelines to the type of picking and storage equipment to be used are based on product size, number of order, speed of through-put and size of inventory (Gwynne, 2014:133)

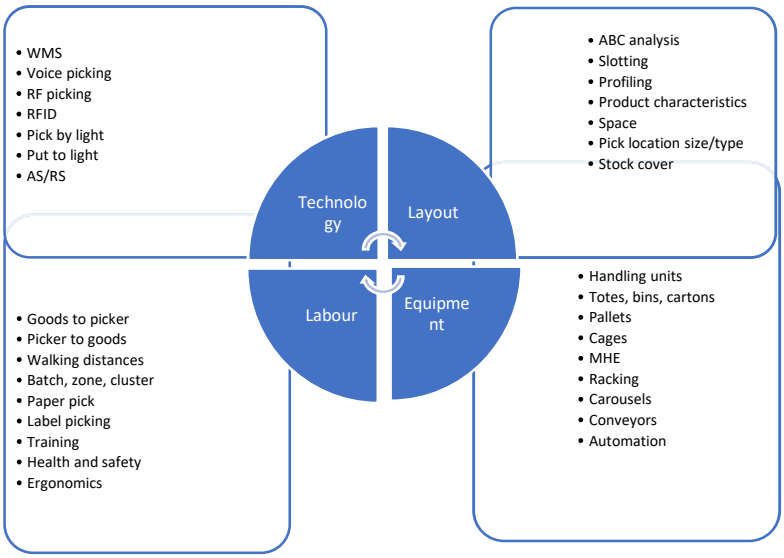

Figure 3.5: Shows the Inter-relationship between Labour, Technology, Equipment and Warehouse Layout

Source: WERC (2012:22).

3.7.4.3 Order Picking Methods

Firms focus on the picking processes as the location in which efficiency can be improved and have a significant effect on overall cost. The basic purpose here is to affirm that picking precision is estimated before the request leaves the warehouse, with the goal that workers can know their performance and extra training initiated whenever required (Gwynne, 2014:78). To achieve this, staff need to be well trained and operations continually improved. This demands that information and feedback be given to operators (Pienaar and Havenga, 2016a:15).

The efficiency of a WMS warehouse is in a way higher than when the processes are manually done (Ramaa, Subramanya and Rangaswamy, 2012:1), since mistakes in all processes are carefully controlled (Vogt, 2016b:346). EDI can be used in improving internal effectiveness and efficiency, saving time and resources, and thus reducing organisational costs (Fallah, 2011:203). Improved accuracy can be achieved by decreasing the number of times and the number of people involved in data entry. With this EDI connect set up between suppliers, manufacturers, retailers, customers and the banks, a completely paperless supply chain is now possible (Asadi,2011:238; Aleksandar, Aleksandar and Dejan, 2011:533).

A decrease in paper work and process time will result in a decrease in human error, and would improve a logistics system's efficiency through speed, precision and reliability (Hu, Shi, Voß, and Zhang, 2011:209 ; Eckhardt and Rantala, 2012: 614). However, Aberdeen Group (2009:15) observed that 70% of best-in-class organisations are more probable than other organisations to accept products without utilising paper documents. All have moved to the utilisation of barcodes, RFID or voice technology. In a similar study by Gwynne (2014:146), it was shown that various producers have presented a joined voice and automated guided vehicle (AGV) or laser guided forklift truck system. By implementing both systems simultaneously, productivity improved by up to 70 %.

3.7.4.4 Storage and Handling Equipment

There are several storage systems and manual handling equipment currently used in modern warehouses. There are just two desired locations of storage in a DC/WH: the long–period storage zone (including the pick face) and the dispatch gathering zone, where products are collected to create a load. At all additional areas where products are at rest, for instance, the receipt area are reflections of effectiveness (Vogt, 2016b:333). One vital area determining the efficiency of the warehouse is the identification of the most appropriate storage locations for potentially thousands of products in a warehouse. The cubical space should be effectively utilised and adequate racking installed (Ramaa, Subramanya and Rangaswamy, 2012:15). Stockpiling in racks is a cost-effective method of increasing the volume of goods on each floor space (Vogt, 2016a:264). But interestingly, even in modern warehouses, the most popular forms of storage noted for the group of companies surveyed was floor storage and standard aisle racking (Baker and Perotti, 2008: 72). There are several advantages associated with block stacking, including access, damage, stock rotation and space utilisation (Gwynne, 2014: 222).

In the case of MHE, Gwynne (2014:254) submits that most of the manufacturers have sophisticated mechanical handling and storage equipment systems, including simulation software that assists companies to decide on type of racking. MHE efficiently suited their operations. An investigation by Baker and Perotti (2008:64) into the kind of equipment used in UK warehouses established that there remains a substantial dependence on the picker-to-goods system, with the use of pallet trucks,

lift trucks and shelving and racking as storage options. In addition, organisations used a combination of equipment to handle different types of products and order profiles. The significance of appropriate utilisation of MHE cannot be overemphasised. As indicated by Rajes and Subbaiah (2015: 117), the utilisation of MHE results in reducing the labour of workers by reducing forces in lifting, handling, pushing and pulling material. The result will be an increase in productivity, product and service quality and lifting of worker's morale. In addition, there is reduction in damage to material through human error and negligence, and a reduction in fatigue and injury when the environment is insecure or inaccessible (Kay, 2012:20). Despite the benefit of picking equipment, Peerless Research Group (2012:18) revealed that 70 % of the respondents in the United States planned to spend less than 250,000 dollars on warehouse equipment in 2013 with only 11% contemplating the purchase or evaluation of automated systems.

3.7.4.5 Packaging for Logistics Efficiency

Packaging is among the primary target areas on which transporters pay attention to enhance transport process efficiency. The objectives are to lessen the weight of individual goods, while increasing the quantity of products that can be transported on each vehicle or in each container (McCue, 2010:30). Packaging configuration such as, kinds of materials utilised in packaging, information and standardisation of packaging affects efficiency and effectiveness of numerous logistics processes in terms of choice of vehicle type, cubic capacity and tonnage (Nilsson, 2016:295). Manufacturers should be educated to use only those standard pallets and containers, to minimise transport and handling costs (Link 51 Project Management, 2010:4). The size aspect influences the utilisation of a warehouse space.

Packaging must be treated as a system to obtain full benefit and not just as detached parts addressing consumer attractiveness, production or logistics efficiency. The manufacture, use and disposal of packaging represents 60% of total production costs or between 15% and 50% of the selling price of a product (Nilsson, 2016: 295). From this, we can see that packaging is closely related to logistics activities. Owning to increasing requirements for sustainability and sustainable development, the role of packaging is essential to the environment as well as having a social impact (Nilsson,

2016: 295). Due to quick exchange of information and planning of the required number of workers and other resources used in the packaging process it is possible to speed it up by 34% (Andrejić and Kilibarda, 2016:145).

3.7.4.6 Loading and Offloading in Warehouses

Loading and offloading of vehicles takes place at the manufacturers warehouse and the terminals. The next section discusses vehicle loading and offloading equipment and the period of loading and offloading at the terminals.

3.7.4.6.1 Vehicle Loading Equipment

The receiving processes include offloading goods from the vehicle at an offloading bay, sorting the goods, confirming the numbers, and (haphazardly) examining the quality of the goods. The influx of delivery must be arranged with the goal that the facility can afford the staff to undertake the offloading; the instrument used to move the products and the ability to deal with any differences between the stock requested and received without this arrangement, the outstanding task at hand in the store will vary unduly (Gwynne, 2014:148; Vogt, 2016b:334)

For the maximum benefits of specialisation to be achieved, handling tools at the nodes ought to offer fast loading and offloading of products to make best use of the quantity of full vehicle load kilometre per unit of time. Economies of density require the optimal use of big, strong equipment over as long period as possible (Pienaar, 2016c:381). These include automatic loaders, high level cranes, forklifts, manual, loader shovels, excavators, overhead gantries and utilisation of saddle carriers. These vehicle equipment permit additional grades of movement for handling unit loads (Hannan, 2011:32). Block manufacturers usually utilise self-loading vehicles with cranes mounted on the edge or on a removable mounting. Big quarry trucks are usually loaded by shovel loaders while smaller vehicles are often stacked by an excavator. Manual loading may utilise less effort by way of a low truck and body. Detachable bodies or containers can be left on the ground for loading and lifted on to the truck by a hydraulic or mechanical crane (Rushton, Oxley and Croucher, 2001:370).

Trailer trucks are designed fundamentally for the transportation of bulk freight that is not moisture retentive. In any case, the trailers trucks cannot tip to dump their payload

or be turned upside down to be emptied. Hence, they should be loaded and offloaded mechanically utilising fork lift or crane and by hand from the top (Pienaar, 2016d:354). It is important to note, Michael (2015:16)'s submission that each point of stockholding comprises handling of the material and, the more numerous the handling of material, the more the total logistics expenses would be. This is because the process includes both equipment and human effort. This represents the cost of workforce in the warehouse and automation utilised to receive, put away, move, check and count inventory (Parvini, 2011:156). It should be noted that efficiency of offloading processes could be enhanced by 61% with information system advances (Andrejić and Kilibarda, 2016:145).

3.7.4.6.2 Period of Loading and Offloading at the Terminals

Several customers receive products not only within working hours, but very early in the morning and later in the evening. The use of a vehicle that usually runs from 08h00 to 16h30, or for 8.5 hours, can be significantly improved if it can deliver goods between 07h00 and 08h00, thus avoiding peak traffic hours in the cities. The same would apply if deliveries can be made at night (Vogt, 2016b:342). Regardless of whether the delivery is optimised by a system or not, extended hours and flexible delivery times would significantly improve productivity. These times are bargained between the manufacturers, DC/WHs, customers, suppliers and facilities within the logistics chain. Again, the reduction of restrictions, in this case customer receiving times, improves the potential for increased efficiency (Vogt, 2016b:342). A few cities in the United States and European Union (EU) have implemented day time restrictions on truck deliveries in their downtown core areas (Ruamsook and Thomchick, 2012:142). This has a negative impact on logistics efficiency as it creates longer waiting times for vehicles at the terminals.

3.7.4.7 Processes from Replenishment to Dispatch

The other warehouse processes comprise replenishment, services which are available at little or no cost, and promote their primary business (value-adding services) and dispatch, together with the fringe job of inventory and housekeeping. This too involves safety efforts required within the warehouse. For a smooth, efficient pick process, one must guarantee that the correct goods and numbers are in the right pick locations. The outcome of a poor replacement procedure is demand deficiency, increased picking

time and therefore, increased cost per pick and an overall reduction in service level (Gwynne, 2014: 138).

WMS will recognise when it is essential to replace pick sites through continuous information exchange. These networks do detect the complete demand quantities and swiftly refill before the subsequent influx of orders. Information is immediate, and continuous information exchange is priceless. The use of a WMS can enhance speed, productivity and accuracy (Gwynne,2014:202; Vishnu, 2016:166).

3.7.5 Effectiveness in Warehousing

Effectiveness can be measured by how much the required level of service is given to meet expressed goals and objectives (Pienaar and Havenga, 2016b: 25). Gunasekaran, Marri and Menci (1999:330) developed a model to increase the effectiveness of warehousing procedures, here presented in Figure 3.6. The two main areas for improving warehousing processes are Just-In-Time (JIT) and Total Quality Management (TQM). The JIT philosophy in warehousing processes manages demand pull and minimal economic quantity. It reduces Work in Progress (WIP), supplier dependability, preventive maintenance and removes buffers. TQM deals with long-term responsibility, the war on waste, continuous improvement, Total Quality Control (TQC), continuous training and ergonomics. JIT helps in planning the processes, decreasing lead time, inventory, through-put time and improves on-time delivery to different locations. TQM supports improving the effectiveness and quality control of warehousing processes (Gunasekaran, Marri and Menci, 1999:330).

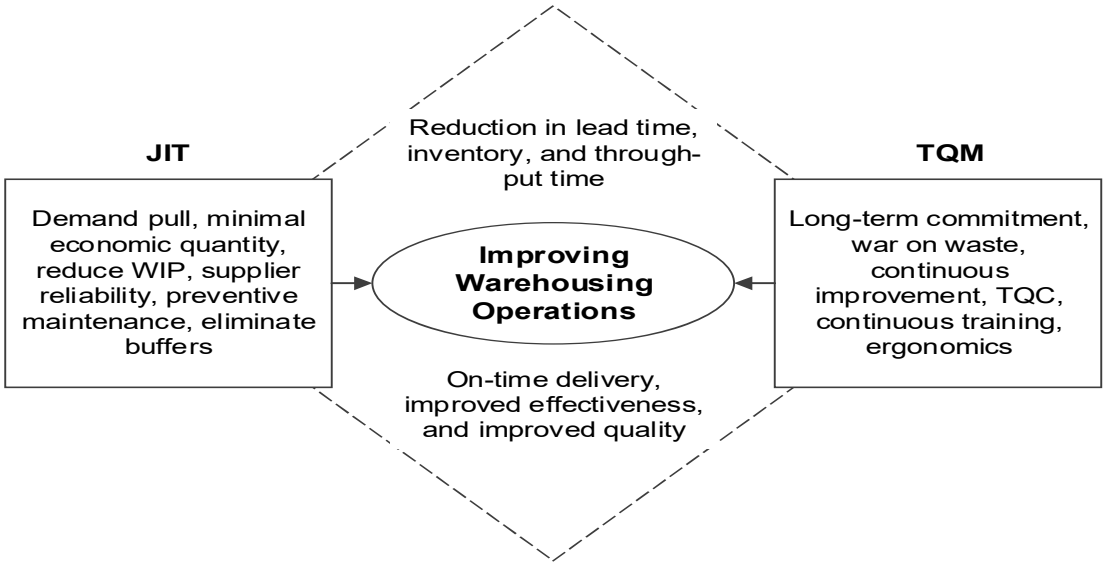

Figure 3.6: Model for Improving the Effectiveness of Warehouse Operations

Source: Gunasekaran, Marri and Menci (1999:330)

3.7.6 LEAN Warehousing

LEAN Management began in the manufacturing subdivision, even more accurately the car business. It is related to Toyota and the Toyota way. Applying a LEAN Inventory for the storeroom is just as important as is considered in manufacturing. The primary objective of LEAN Management is concentrating just on what you need and nothing more. This would probably lessen or remove safety stock and get suppliers to transport lesser quantities more often (Vishnu, 2016: 167). The thought is to classify the operations inside a warehouse that engross resources, but don't generate extra value (Gwynne, 2014:43). Gooley (2013:23) discussed the seven wastes or Muda that LEAN Administration tries to eliminate. An example in the pallet extractions would include the following:

i. Transportation (driving an unfilled forklift);
ii. Defects (time spent rectifying mistakes, such as miss picks);
iii. Motion (interrupting movement, such as stacking products before put-away);
iv. Waiting time (jams at pick locations);
v. Inventories (congestion at the inbound and outbound areas);
vi. Overproduction (holding excessive amounts of stock); and,
vii. Over processing (performing needless steps, such as labelling and checking).

A study where RFID is integrated with LEAN Production in both CDC and LDC revealed a significant improvement in the entire supply chain, thereby saving 89% and 70% on waiting and transportation times, as well as value-added time respectively (Chen, Cheng and Huang, 2013: 3396).

3.8 Efficient and Effective Inventory Management

The basic purpose of inventory management is the holding of an optimum level of inventory required to sustain the production system, and with the minimum cost possible. Findings have shown that there is an important relationship between good inventory management and organisational efficiency and effectiveness (Anichebe and Agu, 2013:94). Inventory planning includes the setting of optimal inventory levels in the logistics system, with due thought for the least overall logistics costs and uncertainty in demand and supply. Estimates that are not carefully thought out may bring about either excess inventory or diminished stock. Consequently, manufacturers and wholesalers need to plan for adequate inventory to satisfy demand (Anichebe and Agu, 2013:94). Mostly, inventory planning depends on future demand estimates flowing upstream from the supply chain. However, in the construction sector, efficient inventory planning is hampered in ways that contractors cannot quickly identify, and hence, they cannot accurately convey demand before the contract is awarded (Vidalakis,Tookey and Sommerville, 2011:77). Nonetheless, understanding of certain inventory concepts is essential for effective inventory management.

3.8.1 Concepts for Effective Inventories

The concept that is most important for understanding the planning of optimum inventory levels is availability. It refers to the ability of the business to have inventory when desired by a customer. The reason for holding inventory is to have products available. There are three approaches in which availability is usually measured in practice. They are stock out frequency, fill rate and order shipped complete (Cronje, 2016:228).

i) Stock out frequency - A stock out happens when demand surpasses availability. Stock out frequency refers to the probability that stock out will occur, and measures how many times the demand for a specific product surpasses availability. The total of

all stock out for all products supplied by the business gives an indication of how well a business succeeds in basic customer service commitments.

ii) Fill rate – While the stock out refers to the possibility of a stock out, the fill rate measures the extent or effect of out of stock after some time. The simple fact that a product is unavailable does not imply that the request won't be met. For instance, if a customer orders 100 units and just 90 are supplied, the fill rate is 90%.

iii) Orders shipped complete - Orders delivered complete (order fill) is the strictest measure of availability. It is the calculation of percentage of occasions that a company can deliver completely the items requested by a customer from the available stock. Order fill is calculated as the percentage of the customer's order that can be provided completely.

3.9 Technology Adoption in Logistics Processes

Technology is the medium that is improving supply chain competitiveness and performance. It improves the total effectiveness and efficiency of a logistics system. In response to the paradigm shift in technology, the worldwide competition and the demands of product assortment, an enormous level of conventional manufacturing is experiencing organisational transformation and technology investment that make factories smarter and more efficient (Mayyas and Sarder, 2018:14). Thus, selecting the right technology for different logistics operations or sub-processes is critical for any business to increase competitive gain in current markets (Bhandari, 2013:24). Information can be viewed as the life blood of a logistics system and it acts as a glue in logistics roles, holding the network together and managing all components of logistics (Asadi, 2011:221). The adoption of automatic identification, communication, information technology and e-business in logistics processes is therefore critical.

3.9.1 Automatic Identification Technology

The adoption of barcoding, voice technology and picking-by-light systems are not only enhancing warehousing picking processes, but also making a satisfactory return on investment (Gwynne, 2014:138; Vishnu, 2016:166). A study by Biju and Faisalu, (2013:147) established that most organisations use bar coding now. They opined that most AutoID software is essential and should be implemented. Bar codes improve

efficiency in three ways: speed, accuracy and reliability (Sople, 2010:77; Bhandari, 2013:21). Owing to online data communication to central computers, there would always be continuous information updating.

Scanner tags and RFID would improve material monitor location and documentation processes, as well as efficient identification and location or condition awareness. Continuous online information on the location of the materials would remove the physical monitoring of materials by security agents (Equere and Tang, 2010:104). The benefits of AutoID comprise accuracy, cost saving, speed and convenience of information storage and processing (Bhandari, 2013:20).

3.9.2 Communication Technology

Communication software is not just improving efficiency in the delivery and collection process, it also empowers companies to give much better customer service. It permits the customer to follow a product's location, thus offering a more exact predicted time of arrival. It enables addressing a problem from the start and puts the delivery of a product back on schedule. The majority of the tracking and monitoring platforms are just web based real-time systems that operators can access from any location that has internet access and a web browser (Ruamsook and Thomchick, 2012:135; Kasim, 2015:218).

Communication on vehicles has also improved with technology. VSAT helps in having up-to-date information on the position of a vehicle and the delivery location. GIS, in combination with GPS, is utilised in logistical processes for monitoring and tracing of the shipment location to the exact road in a city (Bhandari, 2013:20). Data sharing practices like VMI give producers access to more exact demand information (Shukla, Garg and Agarwal, 2011: 2064). Based on the Control Theory of Automation, the entire process is automatically controlled and recorded. Inventory activities are computerised to make it easy to locate stock in a warehouse (Ndonye, 2014:7).

3.9.3 Information Technology

Organisations must embrace IT software, including enterprise applications such as ERP, CRM, DRP, AITS and RFID, in addition to e-procurement and e-commerce (Marinagi, Trivellas and Sakas, 2014:586). A system completely computerised will

lead to constant monitoring at three stages, specifically at production sites (off-site), en-route (shipping) and construction sites (on-site) (Sardroud, 2012:381). DRP enhances stock visibility in the network, leading to reduction in stock level and distribution centre space requirements (Bhandari, 2013:23). ERP data networks reinforce manufacturing procedure and construction project related information (Tambovcevs, 2012:66). This enables a more rapid response to customer requirements, a decrease in inventory costs, an enhancement in service at internal and external levels, an improvement in stock turnover rate and a decrease in logistics costs (Bhandari, 2013:20; Zhong, Dai, Qu, Hu, and Huang, 2013: 283).

For logistics to be effective, there should be appropriate information sharing, trust and teamwork among the partners. These can be achieved by the appropriate adoption of new information technology software in the management of logistics systems (Biju and Faisalu, 2013:139). An investigation by Wilson, Iravo, Tirimba and Ombui *(*2015:18) revealed that the full adoption of ERP, JIT, RFID, VMI, and having a separate Logistics Department, are not frequent among manufacturers. However, the higher the level of Information Technology use in companies, the more effective and efficient the logistics system will clearly be.

3.9.4 E-business Adoption in the Logistics Process

In terms of e-business effects, this relates to decrease in cycle time and quality enhancement, rather than direct cost reductions as cited by other scholars (Matopoulos, Vlachopoulou and Manthou, 2009: 853). E-procurement has turned out to be common because of real time exchange information and funding at the same time (Sharma and Sahu, 2014:140).

The emergence of the internet and electronic communication has simulation or improvement based IT answers included in a wide variety of models that cover many aspects of logistics (Voigtmann and Hans-Joachim, 2010:3201). This also improves schedules based on logistics (Said and El-Rayes, 2014:111). To improve material delivery by allocating packages to trucks and selecting the best roads, vehicle routes can use milk runs or direct delivery based on project requirements (Hamzeh, Tommelein, Ballard and Kamansky, 2007: 184).

Cronje (2016:250), asserted that CPFR is a process started by the FMCG business to organise the individual estimates of various members in the supply chain. It is a business practice that integrates the ability of some business associates in organising for customer satisfaction (Sari, 2008:498). A study by Matopoulos, Vlachopoulou and Manthou (2009:10) found that the adoption of e-business in the logistics process was not entirely a matter of resources. Despite what might be expected, operational compatibility and the level of teamwork are two factors that assume a determining role in improved e-business adoption and impact.

When it comes to customer relationships, the internet offers an efficient way to exchange information with them. Associated with the adoption of the internet is the efficiency of the order satisfaction process for both web-based and offline companies (Giménez and Lourenço, 2008: 308). Having a computerised, combined network that interfaces related departments such as sales, accounting, marketing, warehouse, manufacture and shipment and coordinates the information among them would significantly influence correct and reliable responses to customers, thus ensuring customer satisfaction (Fallah, 2011: 203). Johnson, Klassen, Leenders, and Awayshehet (2007: 1255) stated that knowledge of how and where companies utilise e-business, and the immediate benefits that they offer, is still limited.

3.10 Economic Efficiency

The economic perspective speaks to the financial needs of partners (customers, workers, suppliers, investors), ensuring that they are met effectively and efficiently. The social dimension focuses on human rights and workers' health and safety. The ecological aspect guarantees waste minimisation, emission reduction and protection of natural resources (Bansal and Mcknight, 2009: 26). Triple Bottom Line is usually called: People, Profit and Planet (3Ps).

Economic efficiency is about making the best use of the total or collective welfare of the members of the public. Economic analysts say that efficiency needs the fulfilment of three elements to enable an increase in net benefits. They are productive, allocative and dynamic efficiency. An economically efficient choice implies that no other choice can give more net benefit (Productivity Commission, 2013:4). If a decision is

economically efficient, it must likewise be one that provides the maximum cost effectiveness. Cost effectiveness investigation is regularly utilised as a substitute to cost-benefit analysis (that the overall benefits of an activity surpass its total cost). Here, it is less demanding to evaluate the anticipated results than it is to value them (Productivity Commission, 2013:4).

3.11 The Concept of Productivity

Measures of efficiency differ on how inputs and outputs are calculated (Borotvás, Tánczos and Tóth, 1980:122). The most common form is labour productivity, assesses the total labour required to produce an output. Production efficiency integrates technical efficiency, which reveals the level to which it is technically possible to lessen any input without reducing the output, and without increasing any other input (Productivity Commission, 2013:11). Personnel productivity means the quantity of output divided by the number of people employed to produce the output. The following human resources-related productivity measures were shown to be relevant to logistics management (Kussing and Pienaar, 2016:526):

i. Comparison of actual versus target achievement;
ii. Number of units delivered per human resources cost;
iii. Number of units carried/ delivered per warehouse/ transport employed;
iv. Average order cycle time; and,
v. Comparison to historical standard.

3.12 Human Skill and Experience

The staff members performing work should be given proper training to satisfy the skills required for their jobs. This includes awareness of the significance and position of their actions and how they add to the achievement of the quality objectives. Employment conditions, multi-skilling and empowerment of the company's workers can accomplish better practical flexibility (Charles, 2008:9). Teamwork permits the sharing of abilities and expertise among groups in warehousing operations (Gunasekaran, Marri and Menci, 1999: 329). The absence of logistical know-how will reduce a company's ability to direct their desired processes effectively (Abimbola, Charles and Akinlabi, 2014: 01).

Ackerman (2000:77) points out that effective supervisors and managers support an open interchange of ideas and have regular deliberations with their staff and peers. They ought to have these nine basic attributes:

i. An ability to delegate effectively;
ii. Excellent communication skills;
iii. Motivational aptitudes;
iv. Problem-solving aptitudes;
v. Flexibility;
vi. A comprehensive knowledge of company processes and procedures;
vii. Ability to train others;
viii. Be customer oriented; and,
ix. Teamwork aptitudes.

Training across disciplines affords the operator a sense of development and builds flexibility into the process. Effective training helps to motivate staff and should be a continuous procedure (Gwynne, 2014:57). Individuals will perform their task efficiently once they are trained to do each job in the best way and are given adequate time to carry out their work to avoid error. Appropriate, formal training is the best way of avoiding mistakes (Vogt, 2016b:333). The training programme for operatives should focus on increasing planning and ordering logistics efficiency among partners (Ying, Tookey and Roberti, 2014: 263).

3.13 Customer Satisfaction

A research study by Reichheld and Teal (2001:76) established that, for some organisations, a rise of 5 % in buyer retention can improve proceeds by 2.5% to 95% Furthermore, the study discovered that it costs six to seven times more to woo a new customer than to retain a current one.

From a warehouse viewpoint, this implies that one must guarantee precision, quality, aptness and cost-effectiveness in the operations one controls. By addressing this, one adds to efficiency of the operation and consequently, to customer fulfilment and retention (Gwynne, 2014:293).

A recent study in the United States by WERC (2012:14) identified 12 metrics as the performance measures most commonly used in warehouses. Out of the 12 metrics, there are four most popular customer-based metrics which are central to effective customer satisfaction. These four metrics are:

1. On-time shipments;
2. Internal order cycle time in hours;
3. Total order cycle time in hours; and,
4. Order picking accuracy.

Three of the main four were customer-based measures, even though order picking accuracy is categorised as a quality-based measure. However, it directly impacts on customer satisfaction. These metrics have been joined by the perfect order metric. This does not only require on time, in full delivery, but also that the product must be damage free and has an accurate invoice (Gwynne, 2014:304). These customer metrics are discussed under perfect order indicators and total order cycle time below.

3.13.1 Perfect Order Indicators

WERC (2012:142) defines a perfect order as complete, delivered on time, damage free, and with correct documentation and pricing/invoicing. The customer's satisfaction might be more in benefit to low cost, on time shipment; to deliver on or before the promised scheduled due date, or receiving a customised product (Pegels, 2005:56; Landrum, Prybutok, Xiaoni and Peak, 2009:77). Berry, Bozarth, Hill and Klompmaker, (1991:364), add that shipment reliability is at times referred to as trustworthiness or on-time delivery and concerns the ability to deliver according to agreed dates.

Notwithstanding the underlying logistics cost, products must be returned and replaced. Such unexpected deliveries typically cost more than the original distribution. Thus, responsibility for zero-defect order-to-delivery performance is a major goal of leading-edge logistics (Bowersox e*t al.,* 2013:42).

Producers, wholesalers and retailers are generally concerned with accurate post-sale policies that would enable them to improve customer satisfaction levels (Kurata and Nam, 2010:137). Therefore, Pienaar and Havenga (2016b:34) emphasised that

feedback must be obtained directly and clearly from the customer. In doing so, the following measures are most critical:

i. Percentage of loads received at the correct place;
ii. Percentage of materials received damage free;
iii. Percentage of products received complete;
iv. Percentage of orders fulfilled accurately; and,
v. Percentage of orders billed accurately.

A delivery feedback study by Manrodt, Vitasek and Tillman (2014:8) revealed that on time shipment was rated at 85.8%, order filling accuracy 73.2% and order fill rate 50.7%. Even though the study indicated slow but stable enhancement in operational performance, it highlighted significant opportunities for improvement. Customers who collected orders on time, in accurate numbers, damage free and with accurate documentation usually pay their bills sooner (Peter, Karl and Vitasek, 2008:1).

Honeywell (2008:1) outlined procedures and technologies that could improve accuracy and perfect-order performance as presented in Table 3.2. It demonstrated that improving performance in one area may include making changes beyond the procedure itself.

Table 3.2: Processes and Technologies that can Improve Accuracy and Perfect Order Performance

Metric	Goals	Technology Enablers
On-time Delivery	Streamline receiving, put-away and picking.	Integrated WMS, wireless computing to manage receiving put away and picking.
	Speed check-in, loading and check-out operations with automated documentation.	Advance shipping notices/ Electronic Data Interchange (EDI) and mobile computers enable quick scan of barcodes and reduce time to receive loads. Validate outbound shipments with barcoding and RFID.
	Reduce drive time and track shipments en-route.	GPS and/or wide area wireless communications to redirect and track deliveries.
Complete Orders	Identify and record items as they are received.	Area imaging technology allows scanning barcodes at any orientation, from 6 to 50 inches away providing efficiency in the warehouse.
	Improve receiving and put away.	Use mobile printers to generate barcode labels right at receiving.
	Pick items accurately.	Speech technology with mobile computing and barcode systems raises accuracy levels.
Damage-free Delivery	Provide documentation that goods were shipped and delivered damage free.	Mobile computers with integrated imager to take picture and show goods delivered damage free, also with signature capture for proof of delivery.
Accurate Invoicing and Documentation	Provide documentation information to customer.	Advance shipping notices/ Electronic Data Interchange (EDI) provide documented information to destination receiving operations.
	Prevent customer invoice disputes.	On-site signature with mobile computers & on-site invoice generation with mobile printers.

Source: Honeywell (2008:4).

3.13.2 Total Order Cycle Time

The total order cycle time is possibly the best assessment of adaptability as it covers all aspects of the customer request process; how the request is taken care of at first, regardless of whether stock is available, how fast the request is treated through the warehouse and, lastly, how speedily the goods can be transported to the customer (Gwynne, 2014:295). Internal cycle order time is the measure of duration from when an order is received up to the point when the order is ready for delivery. The total order cycle time is the measure of elapsed time from receipt of order until the customer receives the product (this includes internal cycle order time and transportation or transit time) (Ecklund, 2010:6).

Warehouse efficiency is vital to effective handling of the supply chain and achievement best performance. Technology is the driver in this respect. An investigation was conducted on three distribution centres where one had mechanised WMS, and the other two distribution centres were run manually. It was established that with WMS, the internal order cycle duration decreased from 773 minutes to 236 minutes, and the non-value added duration decreased to 95 minutes (Ramaa, Subramanya and Rangaswamy, 2012:1). Order handling processes used to take as much as 70% of order-cycle duration time, but this has been clearly decreased with the assistance of leading-edge technologies such as EDI (Fallah, 2011:203). EDI can be used to enhance internal effectiveness and efficiency, and redeemable time and resources, thereby reducing managerial costs. Better precision was achieved by decreasing the number of times and the number of people used in information entry (Asadi, 2011:238). With ERP, order cycle times can be decreased, bringing about enhanced throughput, customer reaction times and shipment speeds (Cotteleer and Bendol, 2006:48). For Management-CMLS, the purpose of better logistics customer service is to guarantee that materials are adequate and accessible for construction processes.

Regarding administration of customer relationships, the internet is an efficient means of communicating with customers (Gimenez and Lourenço, 2008:309). Having a computerised, collaborative network that links related departments such as sales, accounting, marketing, warehousing, production and transportation, and coordinates the information between them, would positively influence accurate and reliable responses to customers, ensuring customer satisfaction (Fallah, 2011:203; Chen, 2016:7). An efficient and effective logistics system needs a collaborative approach where all the components of logistics must be considered to get a balanced service level that incorporates transit time, reliability and cost (Islam *et al.*, 2013:6).

Research by Shang and Liu (2011:601) established that late shipments often occur in several industries. Poor delivery reliability to customers has a long-term negative influence on them. The reduction of lead-time is an unavoidable component of current time-based processes (Sajadieh Jokar and Modarres, 2009:2484). Timely and accurate information is likewise crucial for reducing the total order cycle time and for

enhancing the flexibility and responsiveness of the logistics system (Apte and Viswanathan, 2000:298).

A study of key warehousing metrics by Manrodt, Vitasek and Tillman (2014:13) found that a gap exists exposing substantial chances for improvement in bottom line results. The bottom line results would not be reached without changes on DC/WH, the basics of cost, quality and prescribed standards (Ecklund, 2010:15). Fulfilled and faithful customers mean a secure profit base for the companies. Unsatisfied customers and their complaints cause an increase in costs (Andrejić, Bojović and Kilibarda, 2013: 3930).

3.14 Improving Logistics Efficiency and Effectiveness

Andrejić and Kilibarda (2016:144) proposed a model for improving logistics efficiency. The corrective activities consist of improving information systems; the removal of failures in transport procedure; better warehouse procedure and inventory management; improving utilisation and better turnover. Adopting logistics technology was urgently recommended (Chen, 2016:3). Markovits-Somogyi, Zoltán and Krisztina (2010:371) summarised the components that could facilitate efficiency, such as the use of telematics, sharing of information, enhancement of administration, intra-modality, creation of new methods and adoption of technologies. Generally, reverse logistics must be combined with old logistics systems to formulate an integrated logistics pipeline. The flow may be coordinated with reverse movement of the delivery flow for maximum efficiency (Shakantu, 2005:282). Maximisation strategies are used to place material availability and transport as a competitive advantage, while also maximising the cost trade-off related to delivery, facilities, equipment, staff and other important cost variables (Ecklund, 2010:1).

3.15 Logistics Performance Measurements

Logistics processes are complex, and the parameters are hard to measure. Whatever is monitored can be evaluated, and whatever is evaluated can be improved. Processes for upgrading can be easily identified if there is a technique that measures logistics functions (Kumar, 2013: 2). Using metrics for the evaluation of logistics performance produces an understanding of the supply chain procedures, guides partnership efforts

and maximises supply chain excellence (Fawcett, Ellram and Ogden, 2007:409). The transport and warehouse performance measurements are therefore relevant.

3.15.1 Measuring Transport Efficiency

The performance of a logistics system is mostly noted by the performance of transport systems (Andrejić, Bojović and Kilibarda, 2016:99). The key transport performance measures, for example, vehicle fill, empty running, time use, deviations from route and fuel consumption can advise logistics administrators as they benchmark their processes (Department forTransport (DfT), 2006:27; Andrejić, Bojović and Kilibarda, 2016:99). Supply chain maximisation indicators, such as the combination of logistics functions, routes, truck optimisation and reverse logistics are effective parameters that reveal the status of how effective transport utility is (Shakantu, 2005:154). The most important performance measures in vehicle delivery are, on time pickup, delivery reliability, transit time, lead time and damage-free delivery (Robert and Skender, 2017:276).

3.15.2 Measuring DC and /WH Efficiency

Warehouse performance is critical for a company's logistics accomplishment. The importance of assessing and monitoring total warehouse performance has been emphasised in the literature review (De Koster and Balk, 2008:176; Johnson and McGinnis, 2011: 220). Additionally, studies have been done on the effect of different warehouse metrics, such as ownership, country of origin, region location, lay-out, size, level of technology and automation of warehouse process (Banaszewska, Cruijssen, Dullaert and Gerdessen, 2012: 484; Andrejić, Bojović and Kilibarda, 2013: 3926).

Warehouse performance metrics comprise handling efficiency, space usage, precision, damage, service, cost and stock holding. Accuracy consists of evaluations of position and record precision, the percentage of products picked accurately and the ratio of requests handled accurately (Ecklund, 2010:2; Andrejić, Bojović and Kilibarda, 2013:3929). Offloading and recording of the merchandise and handling orders also determine accuracy in processing. Dependability on a company is a result of on time delivery, fill rates and accuracy (Vishnu 2016:165).

Failures in the transport and warehouse sub-systems suggest defective quality indicators, which might be the reason for lack of fulfilment and grievances by the customer. Failures in the warehouse suggest mistakes in the request handling process (deficiency/surplus in the transport, items, mistakes of items, damages), including additional processes such as poor inventory control. Failure in transport is mainly concerned with shipments that are falling behind agreed dates, damage and loss of material. The importance of avoiding failure in invoicing, monitoring and removal in logistics is recognised. Failure elimination directly influences improvement in the logistics process (Andrejić, Bojović and Kilibarda, 2013:3930).

In summary, using the Analytic Hierarchy Process (AHP), a choice model for evaluating logistics performance measures is recommended. It allows the help of proficient construction materials supply logistics by categorising and isolating the significant components of the decision-making process as presented in Figure 3.7 (Muya, Price and Thorpe, 1997:150). The overall objective is ensuring efficient, cost-effective materials supply. A logistics performance indicator may be defined as a 'metric by which a supplier can be assessed in fulfilling customer requirements, and an enabler is the characteristic of a supplier which makes it feasible for that supplier to meet customer requirements' (Muya, Price and Thorpe, 1997:150). Logistics performance criteria include: "conveyance unwavering quality; adaptability; and lead times" (NEVEM-workgroup, 1989:08)

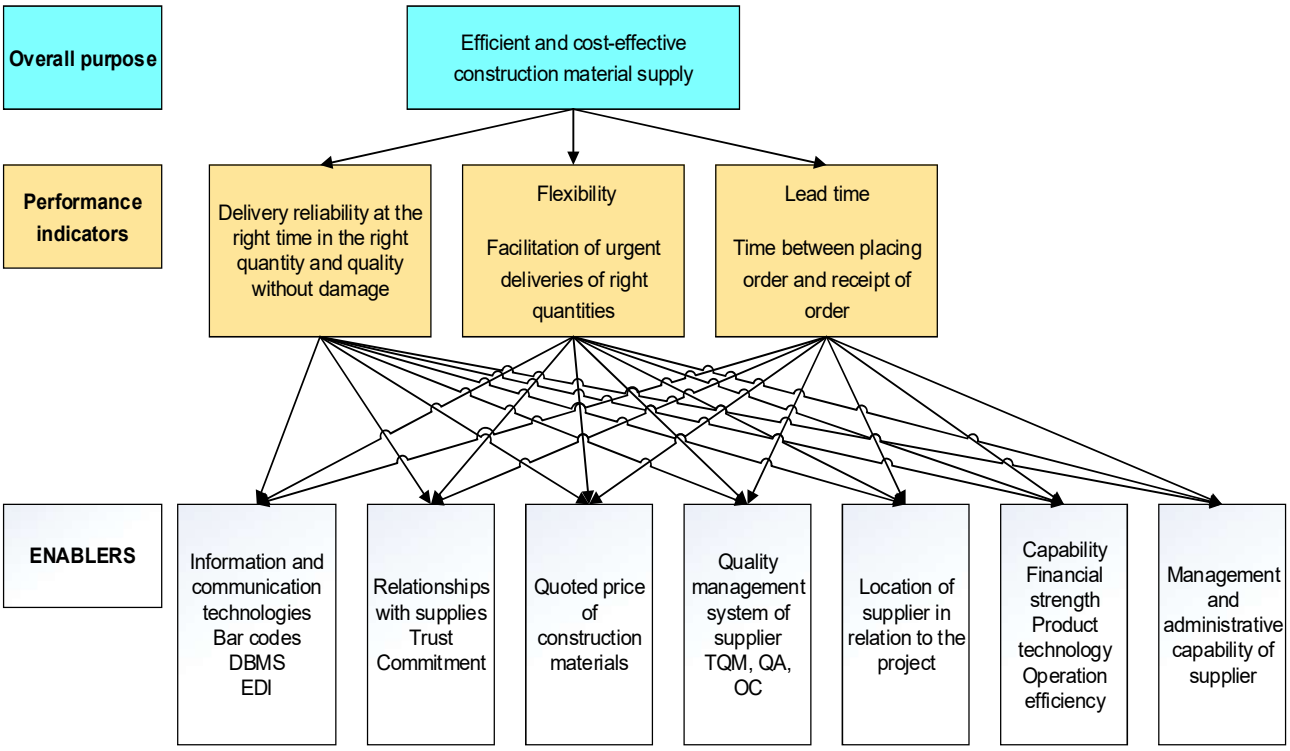

Figure 3.7: Analytic Hierarchy Model for Construction Material Supply Logistics
Source: Muya, Price and Thorpe (1997:150).

3.16 Chapter Summary

This chapter has discussed the theoretical and conceptual frameworks of the research study. It focused on the concept of effective and efficient Management-CMLS as utilised in the Nigerian manufacturing industry. The theoretical framework dealt with the inter-relationships among the core concepts of logistics management. The conceptual framework highlighted the inter-relationships among the concepts of logistics systems, effectiveness and efficiency. This led to the concepts of effective and efficient construction material logistics management at the manufacturer plant, then warehouse and transport subsystems. The next chapter presents the philosophy, methodology and techniques for the conduct of the research.

Chapter 4: The Research Methodology and Techniques

4.1 Introduction

Chapter Four introduces the research methodology adopted to address the research questions and objectives outlined in Sections 1.4 and 1.5 of this study. It begins by considering the problem, aim and objectives of the study, and then proceeds with an explanation of the methodology. The philosophical underpinning and paradigms of the research are then presented. The research design and methods adopted; the nature of the data, its analysis, interpretation, ethical considerations and the research validity are discussed later in the chapter.

4.2 The Research Problem, Aim and Objectives

Section 1.3 stated the main research problem: There is limited knowledge of the management of construction material logistics systems in Nigeria. This research study aimed to investigate the management of systems being used in construction material logistics in North-Central Nigeria.

Section 1.4 stated the Main research question and Sub-questions:

Main Question:

What is the effectiveness and efficiency of the management of construction materials manufacturers logistics systems in North-Central Nigeria?

Sub-Questions:

Sub-question 1: What logistics channels do Nigerian construction materials manufacturers use?

Sub-question 2: What logistics systems do Nigerian construction materials manufacturers use?

Sub-question 3: How efficient are Nigerian construction materials manufacturers warehouse processes?

Sub-question 4: How efficient are Nigerian construction materials manufacturers transport systems?

Sub-question 5: What is the level of utility of technology by Nigerian construction materials manufacturers?

Sub-question 6: What is the level of customers satisfaction with construction material logistics delivery?

Sub-question 7: What strategies can be developed to improve efficiency and effectiveness of Nigerian construction materials manufacturers logistics?

Based on the above problem and research questions, the objectives, methodology, and method of the research were adapted to reflect the aim and the variables presented in the research problem.

4.3 The Research Design

The research design addressed basic issues relating to a research strategy, such as the reason for the study, its location, the type of investigation, the level of researcher interference, time horizons and the unit of analysis (Sekaran and Bougie, 2010:188). The research aim and research problems are the recommended starting points from which to develop a research design, since they give vital information about the substance that a researcher is planning to assess (Saunders, Lewis and Thornhill, 2009:120; Yin, 2012:174). The research design links strategy and a rational arrangement of research approaches in order to address research problems and or hypotheses that are established to study social phenomena (Fellows and Liu, 2008:83; Wahyuni, 2012:70). The research questions give the researcher guidance to decide what, when, where and how the information should be collected and provides a connection between the conceptual and logistics aspects of a research project (Ohab, 2010:14).

For this research study, the research problem was presented through a description of the background of the management of construction material logistics (Management-CMLS) by the Nigerian construction manufacturers. A theoretical framework of Management-CMLS followed, guiding the formulation of a conceptual framework that informed the proposed research method.

The selection of a research procedure relies on the readiness of a researcher to acknowledge the assumptions underlying each set of tools (Rubin and Rubin, 2011:1). Therefore, the choice of a research strategy is influenced by certain philosophical

assumptions because it is difficult to separate a researcher's assumptions and beliefs from the way the research gets to be conducted. The next section presents the philosophical issues underpinning this research.

4.4 Research Philosophy

Research philosophy refers to an explanation of the assumptions about the nature and wellspring of knowledge (Dudovskiy, 2016:6). All researchers rely upon assumptions about the world and use specific methods for understanding the world. There is no agreement among scholars about the most suitable methods for understanding the world. A researcher is therefore required to clarify the philosophy identified and selected to understand the research problem. Research philosophy deals with the source, nature and improvement of learning (Zimkund, Babin, Carr and Griffin, 2012:38).

The perceptions, beliefs, assumptions and the nature of reality and truth in social science research are defined by ontological and epistemological assumptions. They impact on the approaches used in conducting any research, from design right through to the conclusions. It is hence important to know and explain these features, so that the nature and aims of the investigation are understood, and to confirm that the researcher's predispositions are understood, exposed and minimised (Flowers, 2009:1).

To determine the philosophical position of a research study, it is necessary to understand the epistemological and ontological context of the study. The next section examines such ontological and epistemological assumptions.

4.4.1 Ontological Assumptions

Ontological assumptions focus on social reality. These assumptions make claims about what sort of social phenomena does or can exist, the state of their being, what they resemble, what units constitute them and how they are related (Blaikie, 2010:92; Wahyuni, 2012:69). Ontology establishes that the existence of the truth is outside and independence of knowledge seekers and their understanding of it. This is referred to as an objectivist or realist approach (Saunders, Lewis and Thornhill, 2009:140; Neuman, 2011:112).

The two contrasting ontological underpinnings on which scholars can base their techniques are the Parmenidean and the Heraclitean ontologies. The Heraclitean ontology emphasises the ordinariness and importance of a fluxing, altering variable and a new world. The Parmenidean ontology presents the permanent and constant nature of reality (Shakantu, 2014:59). The contrast between the Heraclitean ontology of becoming, and the Parmenidean ontology of constancy, offers scholars an opportunity to comprehend current discussions on the philosophy of social sciences and their implications for research on management.

Flowers (2009:2) noted that while considering that diverse opinions exist with respect to what constitutes reality, other questions must be considered as well: how is that reality evaluated, and what constitutes knowledge of that reality? This leads to questions of epistemology, because each ontological position has an equivalent epistemological position (Eriksson and Kovalainen, 2008:13). The problem being investigated is an objective social reality, requiring investigation and a measurement of discrete and identifiable objects and phenomena. Therefore, the ontological assumption in this study was positivist.

4.4.2 Epistemological Assumptions

Epistemology is the formation of knowledge. It is concerned with questions about how and what is probable to know. Therefore, epistemology is the study of the validation of knowledge (Easterby-Smith , Thorpe, Paul. Jackson and Lowe, 2008;46). To a great extent, the epistemological part of philosophy in research is concerned with the provision of knowledge and the contentions encompassing the likelihoods of knowing (Eriksson and Kovalainen, 2008:13).

Accordingly, the two important examples of epistemology are objectivism and subjectivism (Eriksson and Kovalainen, 2008:13; Shakantu, 2014: 57). The objectivist accepts that knowledge about the outside world is accessible with almost no manipulations. A subjectivist, on the other hand, accepts that it is possible to obtain knowledge about the outside world by observing and interpreting (Eriksson and Kovalainen, 2008:13). Additionally, epistemology provides a philosophical context for determining what types of knowledge are legitimate and adequate (Mack, 2010:5).

This study was based on the conventionalist assumption. Therefore, the research had to be objectivist.

4.4.3 The Combination of Ontological and Epistemological Assumptions

Grix (2004:68) states that research is best done by clearly setting out the correlation between what a scholar thinks can be studied (ontological position); what we can know about it (epistemological position) and what approach can be applied to acquire it (methodological techniques). This correlation enables one to understand the influence that one's ontological position can have on what and how one decides to study.

The epistemological and ontological assumptions create two sets of research philosophy. It is not feasible or reasonable to think of them as being autonomous of one another. Pointing out the separation was basically to emphasise the fact that there are two kinds of assumptions; and that added combinations are possible, and might be reasonable (Blaikie, 2010:95).

Furthermore, the researcher's ontological assumptions dictate his/her epistemological assumptions, which then direct his/her methodology. All these factors influence which approaches can be utilised to collect data. These basic beliefs are summarised in Table 4.1.

Table 4.1: Common Combinations Between Ontology and Epistemology

Ontology	Epistemology
Shallow	Empiricism
Conceptual realist	Rationalism
Cautious realist	Falsification
Depth realist	Neo-realism
Idealist	Constructionism

Source: Blaikie (2010:94)

The ontological and epistemological assumptions have been explained in the foregoing section. It is thereafter essential to position the research context within a relevant research paradigm (Shakantu, 2014:47). The choice of a paradigm has consequences for both the methodology and the research methods. The paradigm is established by the nature of the research problem being examined.

4.5 Research Paradigm

A research paradigm, in the sociologies, defines the extensive basis of reasoning and planning of observations in research (Babbie, 2007:31). It is a set of essential assumptions and convictions with reference to how the world is seen, and serves as a reasoning strategy that guides the conduct of the researcher (Mack, 2010:5; Jonker and Pennink, 2010:112). Paradigms describe the perspectives of the researcher concerning the phenomena that decides which strategies ought to be used to study those phenomena (Donmoyer, 2008:591).

Positivism and phenomenology are two ends of research paradigms, and each paradigm depends on the two assumptions (ontology and epistemology) discussed in Sections 4.4.1 and 4.4.2 above. The following Sections 4.5.1 and 4.5.2 present the researcher's understanding of the contentions around the two paradigms.

4.5.1 Positivist Paradigm

Positivists trust that many scholars who are examining the same realistic problem will produce similar result by cautiously using statistical tests and applying the same research process in examining a big sample (Creswell, 2009:120). Further features of the positivist research include emphasis on the logical technique, statistical analysis and generalisable outcomes (Wahyuni, 2012:71). Objectivist epistemology expresses that reality exists independently from perception; as it were, there is an objective reality 'out there'. Hence, research studies are focused on finding this objective truth (Gray, 2009:18).

An advantage of positivism is that the researcher has a reasonable hypothetical focus of the study at the beginning of the research process. Consequently, control of the research method is much easier. But this research method is weak in providing a thorough understanding of social phenomena. It is hard to examine the meanings attached to social phenomena (Raddon, 2007:7).

4.5.2 Phenomenological / Interpretivist Paradigm

Phenomenology is based on research questions on phenomena of concern that need detailed in-depth investigation, aiming at explanation, comparison or prescription. In this way, the researcher is able to find a more profound understanding of a social

phenomenon (Raddon, 2007:7). The essential interpretivist assumption is that by focusing on the meaning and interpretation of a phenomenon, the researcher is able to increase his/her understanding of the phenomena under examination (Ormston, Spencer, Barnard and Snape, 2013:12). Interpretivists believe that reality is developed by social actors and an individual's view of it (Wahyuni, 2012:71). Since these human viewpoints and knowledges are subjective, social reality may change and can have several viewpoints. Consequently, interpretivists discard objectivism and a sole truth as proposed in post-positivism.

Shakantu (2014:68) proposed how to choose a research method, as illustrated in Table 4.2. This provides further understanding of the relationship between research methodology and methods.

Table 4.2: How to Choose a Research Method

Research Methodology					Research Method			
Philosophy (Approach to knowledge generation)	Epistemology	Ontology	Social reality	**Paradigm**	Data	Direct observation of object reality	People's perception of object reality	Output
Empiricist (a posteriori knowledge)	Objectivist	Parmenidean	Discrete and identifiable objects and phenomena	Positivist	Numbers Empirical Statistical Experimental Quantitative	Field studies Field experiments	Structured Interviewing Survey research	Data processing and Presentation model
Rationalism (a priori knowledge)	Subjectivist	Heraclitan	Fluxing Changeable and emergent world	Phenomenological	Words Observations Qualitative	Action research Case studies	Historical analysis Delphi/ Expert panel Intensive interviewing	Development and Validation Research report (Treatise, Dissertation, Thesis)

Source : Shakantu (2014 :68)

4.5.3 The Philosophical Position of the Research

This research study was designed to establish an understanding of the management of construction material logistics (Management-CMLS) utilised in the Nigerian construction material manufacturers. The nature of the problem required an in-depth study of the phenomena. The aim was to measure the operational performance of

Management-CMLS as utilised in the Nigerian construction material manufacturers. The following philosophical positions applied to the study:

i. The ontological perspective of the research was the Parmenidean worldview of a typical logistical process, information flow and delivery of material from the manufacturers' plant to their customers across the sampled area of North-Central Nigeria. In other words, the output required a representational view of generic construction logistics. Therefore, the social reality is discrete, identifiable objects and phenomena.
ii. Epistemologically, the problem being addressed by this study is an objective problem in need of observation and measurement. A valid field measurement needed to be performed. The variables would include time of delivery, quantity of delivery, distance of shipment, process time, records of fleet vehicles, transportation costs and space utilisation. The study would be based on the conventionalist assumptions. Therefore, the research had to be objectivist rather than interpretivist.
iii. Paradigmatically, the study is positivist because the problem being investigated is an objective social reality, requiring investigation and a measurement of discrete and identifiable objects and phenomena.

The philosophical position of the researcher strongly impacts on the research thinking and consequently, the research data. Therefore, the next section discusses the research rationale, data and method adopted for this thesis.

4.6 The Research Strategies/Reasoning

In responding to research questions, social scholars are confronted with the burden of selecting the best research approach or approaches to answer them. These strategies are usually viewed from the context of a research paradigm (Blaikie, 2010:80). A research strategy, or reason of enquiry, provides the basis and techniques of how 'what' or 'why' questions can be answered. According to Blaikie (2010:79), there are four basic research strategies, each with its own rationale of enquiry and its combination of ontological and epistemological assumptions. These four are the Inductive, Deductive, Abductive and Retroductive strategies. Table 4.3 explains the rationale of the four research strategies and their interrelationship with the research aim, ontology and epistemology. The next section examines two of the strategies.

Table 4.3: The Logic of the Four Research Methods

	Inductive	Deductive	Retroductive	Abductive
Aim	To establish descriptions of characteristics and patterns	To test theories, to eliminate false ones and corroborate the survivors	To discover the under lying mechanisms to explain observed regularities	To describe and understand social life in terms of social actors, meaning and motives
Ontology	Cautious, depth or subtle realist	Cautious or subtle realist	Depth or subtle realist	Idealist or subtle realist
Epistemology	Conventionalism	Falsifications Conventionalism	Neo-realism	Constructivism
Start	Collect data characteristics and /or patterns. Produce descriptions	Identify a regularity that needs to be explained. Construct theory and deduce hypotheses	Document and model regularity and motives. Describe the context and possible mechanisms	Discover every day lay concepts, meanings. Produce a technical account from lay accounts
Finish	Relate these to research questions	Test hypotheses by matching them with data; do explanation in that context.	Establish which mechanism provides the best	Develop a theory and elaborate it iteratively.

Source: Blaikie (2010:80).

4.6.1 Deductive Reasonings

The deductive reasoning strategy in scholarly research is an approach that a researcher can apply when investigating a phenomenon. The scholar starts with the wide and universal knowledge associated with the study, and then steadily reduces the study to more specific issues. The deductive approach is also defined as the "top-down" strategy (Aqil-Burney, 2008:4). An example of this kind of rationale in research would be an investigation that begins with a known theory, and then reduces the scope to a more specific hypothesis. The hypotheses formulated are further reduced in scope when observations are made to allow for the testing of the hypotheses. The particular information that is collected during the research would be then used to test the hypotheses that would prompt the choice of whether to affirm the initial theory (Crossman, 2012:1). Deductions are reached reasonably from available facts (Aqil-Burney, 2008:4).

The 'why' questions are used in social research to look for answers that can be found when full descriptions of the study are provided. The 'why' questions are analysed in deductive reasoning with the help of current theories or by formulating new ones

(Blaikie, 2010:85). The stages followed in deductive reasoning are summarised as follows:

i. Produce a conditional hypothesis that forms a theory.
ii. Infer likely conclusions originating from the hypothesis.
iii. Explain the conclusions and the reason for the surrounding arguments.
iv. Test the conclusions by collecting suitable data and analysing this data scientifically.
v. The result of the test would confirm the theory (Blaikie, 2010:85).

4.6.2 Inductive Reasoning

Inductive reasoning is the opposite of deductive reasoning. The researcher changes from one explanation to wider generalisations and theories. This method is occasionally referred to as the "bottom up" strategy. The procedure includes identifying sequences and consistencies, developing conditional hypotheses that would be investigated and lastly, drawing conclusions to form theories (Crossman, 2012:1). Inductive reasoning is utilised as a part of the quest for understanding and knowledge, setting up a relationship between perceptions and theory. Science uses inductive reasoning to develop theories, the motivation behind which is to eliminate the requirement for continual perception to make statements about reality, utilising expertise to take a broad view on realistic levels of certainty about the future (Fox, 2008:430). Inductive approaches use a less structured methodology to produce rich in-depth information, thus giving clearer understanding of a phenomenon (Sutrisna, 2009:9).

To give answers to the phenomena in question, inductive researchers endeavour to keep their thoughts open for any likely results while advancing additional steps for data collection. In the sociologies, qualitative research approaches have become accustomed to inductive reasoning on the grounds that the reasoning approach underpins widening present theory into a new setting, or to advance understanding and theory where none at present exists (Fox, 2008:430). The inductive approach includes a larger number of uncertainties than the deductive (Aqil-Burney, 2008:5).

4.6.3 Reasoning Strategy Adopted for the Research

The peculiarities of this research inquiry necessitated the adoption of the deductive reasoning strategy. The rationale behind this selection follows: the research moves deductively from theory to data. This is obvious in the review of the pre-existing/ current body of knowledge in Management-CMLS as applied by the construction material manufacturers. This is presented in Chapters 2 and 3 of this study. This current body of knowledge has been used as a source of reference for this study. The review further identified the important academic theories for effective and efficient Management-CMLS. In addition, the variables advanced in the research problems are stated in Sections 1.3 and 1.4.

4.7 Research Method

The discipline of research uses certain well-known techniques in carrying out scientific studies. The guidelines and processes of the techniques are the research methods (Kinash, 2008:3). There are two methods applied in research, the quantitative and qualitative methods. A third is the mixed data. As the name suggests, the mixed technique combines both qualitative and quantitative methods when exploring a phenomenon. Table 4.4 presents a summary of the techniques as they are reflected in scientific research. The quantitative and qualitative techniques are explained in the next section.

Table 4.4: The Research Methods : How They are Utilised

	Quantitative Method	Qualitative Method	Mixed Method
Mode of Approach	Predetermined -Tests or validates theories -Identifies variables to study -Relates variables to hypotheses -Uses standards of reliability and validity -Observes and measures information numerically	Emerging -Focuses on a single phenomenon to enable in-depth study. -Brings personal values into the study, studies the context or setting of participants Collaborates with the participants.	Both predetermined and emerging -Employs both quantitative and qualitative procedures. -Develops a rationale for combining the two procedures -Integrates data at different stages of the inquiry
Questionnaire design	Structured questions	Unstructured questions	Both structured and unstructured questions
Types of data	-Performance -Attitude -Observational -Census	-Interviews -Documents -Audio-visual	Multiple forms drawing on all possibilities
Analysis	Statistical	Text and image	Combines both statistics, and text, could use images if need be
Inquiry strategies	-Experimental -Non-experimental	-Narrative -Ethnographies -Grounded theory -Case studies	-Sequential -Concurrent -Transformative

Source: Creswell (2003)

4.7.1 Quantitative Method

Quantitative research methods try to make the best use of objectivity, replicability and generalisibility of results, and are mostly concerned with prediction. Quantitative techniques are defined as deductive in nature, in the sense that interpretations from tests of statistical hypotheses will result in general inferences about features of a population (Harwell, 2011:149). General inferences are based on observations or experiments that collect, analyse and display the data in numerical form, rather than in theory or narrative form (Karim, 2008:3; Donmoyer, 2008:718). The method requires a choice from between four diverse levels of measurement: nominal, ordinal, interval and ratio. The most essential level is the nominal measurement, in which items, events and persons are allocated to particular groups in terms of their shared

characteristics (Blaikie, 2010:206). Karim (2008:4) presented the abridged assumption supporting quantitative reasoning as follows:

i. Reality is objective, "out there" and autonomous of the researcher, hence reality is something that can be examined objectively;
ii. The researcher ought to stay at a distance and remain detached from what is being researched;
iii. Research is founded mainly on deductive kinds of logic, and theories and hypotheses are tested in a cause-effect order; and,
iv. The goal is to develop generalisations that contribute to theory that enables the researcher to predict, explain, and understand a phenomenon.

The significant point is that a theory must be formed or espoused. The theory must be stated as a deductive argument, and the theoretical thoughts that lead to the conclusion provide the explanation (Blaikie, 2010:86). The objective is to create a generalisation that leads to a theory that allows the researcher to predict, clarify and understand a phenomenon.

4.7.2 Qualitative Method

The qualitative or subjective method comprises analysing words; it states issues connecting people, objects and situations and it focuses on naturally happening, everyday events in their natural situations (Farrell, 2011:6). Here, the study should lead to both a descriptive model as to how the world is, and a prescriptive model stating how the world should be (Wahyuni, 2012:73). Qualitative research includes the use of more than one data collection procedure and applies several non-numerical (subjective) methods to analyse the data.

The significant assumptions of the quantitative and qualitative methods to research studies come from the two ends of the data range. “While the quantitative approach is identified with the deductive-objective-generalising domain, the qualitative approach is related to the inductive-subjective-contextual domain” (Morgan, 2008:683).

4.7.3 Research Method Adopted for this Study

Section 4.5.3 stated the philosophical position underpinning this research as positivist. The research method for this study needs therefore to be objectivist, representational,

generalisable and quantitative. Furthermore, the literature review in Chapters 2 and 3 established that the problem of logistics in construction is not a problem that is widely understood by those within the industry. Consequently, it would appear unscientific to investigate the problem using classic survey techniques. The logistics problem has yet to be properly explored (Shakantu, 2005:172). In short, it may be possible to enquire from practitioners what their understanding of the problem is, but at the moment they are not likely to have any in-depth understanding of it (Hill and Ballard, 2001:112).

More studies are clearly needed on this topic. What is accessible is only on the initial phases of the problem, hence a case study ends up being the most suitable method for this investigation. This choice is supported by McCutcheon and Meredith (1993:239) and Yin (2014:124), who confirmed that when knowledge is available only on the initial phases of the development of the theory, a case study is the suitable method that leads to further knowledge.

The observational methods of either field study or field experimentation would appear suitable for this study as well. Further examination of the problem enabled the researcher to refine these possibilities. The aim of this study was to measure the operational performance of Management-CMLS as applied by the Nigerian construction material manufacturers. Thus, the current operations at the manufacturers' warehouse and their transport delivery provided the starting point to understanding the context of the problem. To conduct a valid field experiment, the variables (order processing time, picking and handling methods, time of delivery, quantity of delivery, type of vehicle, location of next delivery) of the manufacturers' warehouse logistics processes would have to be in the control of the researcher. This type of control would not be practical for an academic researcher in terms of any significant level. Hence, by a process of elimination, the most suitable prime method of research for this problem was established as being a field study.

The field study method was adopted because it allowed for an in-depth study of the Management-CMLS. At the point when the problem being investigated involves understanding difficult phenomena that are not controlled by the scholar, and when the research questions have a 'how' and 'why' nature, at that point it is fundamental

to choose one significant case study that can clearly prove the 'how-problem' (Yin, 2003:86; Yin, 2009:124).

A flawless case study should use a research plan including multi-sites to be examined, and different strategies to examine the data collected (Yin, 2009:125). The decision of several sites over a sole case study is to allow contrasts between the surveyed practices by subjects studied so as to get a broad knowledge of these practices (Yin, 2012:76). The method is suitable for understanding the operation and process under investigation by taking detailed records about the context surrounding the case. The next section discusses the multiple method of data collection.

4.7.3.1 Multiple Method of Data collection

Multi-method research refers to the use of more than one data collection method, as well as using multiple techniques to evaluate this data (Wahyuni, 2012:173). Generally, the application of mixed methods of data collection and analysis is termed 'Triangulation' (Shakantu, 2005:173).This involves applying more than one technique and may include 'within technique' or 'between-method' approaches. More than one research method is utilised on the grounds that each taps different measurement issues (Shakantu, 2005:173).

4.7.4 Unit of Analysis

It is common practice to start an analysis with the assumption that customer service competence is based on the current order entry and processing system. The warehouse operations are based on standard order fulfilment time at existing facilities, and transportation delivery time is based on the capabilities of the current transportation methods. Given these assumptions, current performance provides the starting point for identifying potential service improvement (Bowersox *et al*. 2013: 302).

Based on experience that the nature of construction is input versus output from sites, the node versus links method is by far the most suitable way to observe the logistics system in a construction context (Shakantu and Emuze, 2012:668). This node versus links method was used as the methodological basis for the investigation of the dynamics of Management-CMLS. The nodes versus links method was presented in Section 2.2.3 of this study. This approach allows for the analysis of a logistics system's

two basic elements: transportation and warehousing. This is illustrated in Figure 4.1. The complexity of the logistics system shows the need to be connected, specifically the time and distance relationship between nodes and links, and also the flow of information on products entering, leaving and moving inside the system (Coyle, Bardi and Langley, 2003:188).

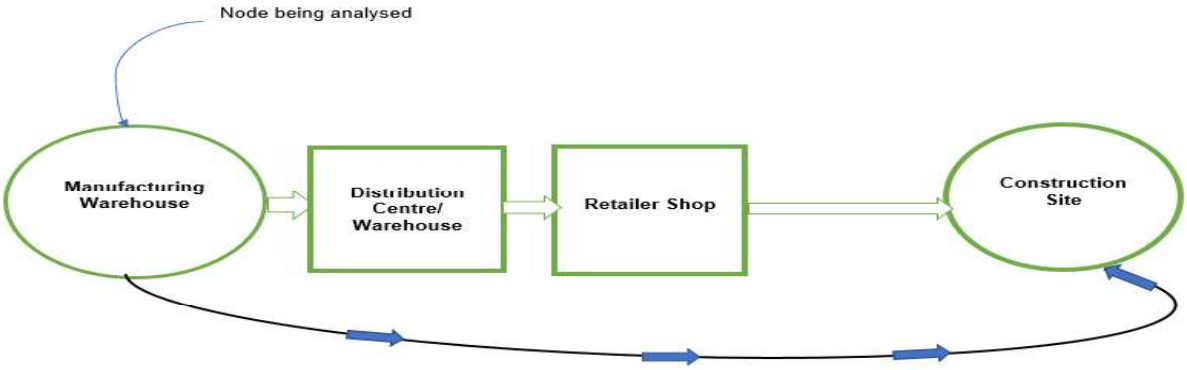

Figure 4.1: The Node Versus Link in a Logistical System

Source: Researcher's design (2019)

In this case, the two links needed to be thoroughly investigated because they give a detailed picture of the delivery of construction material to the nodes, namely, the DC/Warehouse/Retailer stores and construction sites, or within the unit of analysis. By using the node versus link method, volumes of both delivery vehicles entering the DC/Warehouse/Retailer stores and construction sites can be measured. In addition, the internal order cycle time and total order cycle time in the manufacturer's warehouse can be measured. The level of adoption of information technology and automation in processing the flow of information and material delivery can also be assessed.

4.7.5 Development of the Research Instrument

The parameters adopted in developing the research instrument were rating scales which are quantitative descriptions of the characteristics of certain DC/WH and transportation sub-systems (Zikmund, Babin, Carr, and Griffin, 2009:104). These include, measure of the product delivery time (Korpela, Lehmusvaara and Nisonen, 2007:141); measure of distance travelled (Johnson and McGinnis, 2011:222); and the full parameters that were used to measure and analyse vehicle movement (Shakantu, 2005:178).

To understand the type and level of technology/ automation adopted by the manufacturing companies in their Management-CMLS, both lists of pallet storage equipment used in UK warehouses and equipment for order picking by Baker and Perotti (2008:74) were adopted in the research instrument. Furthermore, the instrument also captured the identification of some most recent technologies being utilised in logistics management, classified as Automatic Identification Technology, Communication Technology and Information Technology by Bhandari (2013:21). Five of the most popular customer-based metrics identified by the WERC, 2010:146) were also included in the instrument to evaluate customer satisfaction. These metrics evaluated the following items: On time shipments, Internal order cycle time, Total order cycle time, Order picking accuracy and Orders received damage free.

A non-participant structured observation method in the form of template. An observation and Measurement Guide comprising the afore-mentioned parameters was formed. It was tested on a pilot field study to establish its proficiency in capturing the required data. The instrument was then modified to enrich its effectiveness and improve the speed of data capture. An example of the final version is given in Appendix A.

4.8 Data, their Treatment and Interpretation

This section describes the nature of the data, the population and the sample. It includes how the data was analysed and interpreted.

4.8.1 The Data

The data for a research study could originate from a primary source; a secondary source, or from a mixture of primary and secondary sources (Wahyuni, 2012: 73). In line with the understanding of the research problem and questions, data for this study was obtained from both secondary and primary sources.

4.8.1.1 The Primary Data

The primary data is the novel or inventive material on which the study is based. It is the direct declaration or direct proof of the subject under consideration. This subject is composed by or observed by the researcher. Data in its original form is introduced (University of Victoria Libraries, 2014:1).

This study focused mostly on the primary data, which included the field survey comprising the non-participant structured observation method and the direct measurement of quantitative characteristics of selected operations of warehouse and transportation sub-systems. This data came from records of current order processing operations at pre-transaction, transaction and post-transaction levels. These were based on the established structure related to the conceptual model of this study in order to ascertain what happens in practice.

4.8.1.2 The Secondary Data

Secondary data is published or unpublished work that is one stage far from its novel source (University of Victoria Libraries, 2014:1). The sources comprise related periodicals, conference papers, textbooks, dissertations and theses from research institutions. They are found with the help of library reference services and guiding principles related to the construction materials subsector. These articles and reports frequently discuss early real-world implementation of new policy actions, technological advances in the industry and operational performance (Voordijk, 2000: 828).

4.9 The Data -Collection Methods

Based on the objective of the study, the following data-collection methods were employed.

4.9.1 Archival Records

The respondents are a representative of the total population. The archival records obtained from respondents included:

- number of DC/WHs in the sampled area;
- quantities of materials demanded and supplied to the various DC/WHs;
- frequency of supplies;
- prices of products at companies and DC/WHs;
- transport cost per delivery;
- record of fuel consumption per vehicle in each route;
- vehicle capacity;
- average Store Keeping Unit (SKU);
- standard output for machine; and,

- equipment used in packaging and loading operations.

An examination of the company management, fleet size, gravity area (catchment area – the area that DC serves) was also conducted.

4.9.2 Field Survey

Based on the data collection methods, the observation and measurement stages were employed.

4.9.2.1 Observation

In the observational study technique, the researcher observes an aspect of human behaviour and processes this with as much objectivity as possible, then records the data. In this situation, the researcher tends to record phenomena in its current state (Williams, 2007:67). The demonstrated scenes give observers a chance to reflect on conditions in retrospect. Scott and Garner (2013:122) added that observation offers chances to get the truth of a larger condition, and to draw conclusions that the individual subjects might have difficulty to notice. Observations can be unstructured, semi-structured or structured. Semi-structured and structured involve the development of an observation template (Angrosino, 2005:729).

Angrosino (2005:729) makes two important methodological distinctions:

Objectivist approach to observation

- Related to positivist research.
- Researchers claim that they can maintain objectivity and that they do not influence and interfere with people or activities under observation.
- Researchers adhere to strict rules of rigour that prevent them from influencing/ biasing the data.
- Not being rigorous would involve “going native” – the data would be rendered suspect.

Post-modernist approach to observation

- Related to approaches such as social constructionism.

- Researchers influence and affect the research setting and are very much a part of this.
- Researchers form an “extra pair of hands” in the study.
- Observational objectivity is neither feasible nor desirable, the researcher is part of the production of knowledge.
- Regardless of the above, the Hawthorne Effect created by researchers when conducting observation should be acknowledged.

For this study, time was at first spent on observing and monitoring the current practices of logistics operations and processes on sites. This is said to help the researcher to appreciate and evaluate the quality of present practices (Abdulmohsen and Ruwanpura, 2011:11; Ying, Tookey and Roberti, 2014: 268). This is also in consonant with the recommendation by Kamali (2018:198) that a method like the observation could help more to understand how the on time delivery performance is implemented by firms.

Extensive observations were made to confirm the current order processing, including delivery from the manufacturing companies to DC/WH, retailer stores and construction sites. The two basic processes were information and material flow.

For information flow, the researcher included observation and identification of technology used in data capturing and processing. For material flow, the researcher included the identification of material picking, handling and storage equipment; space utilisation; processes in the manufacturer warehouses and DC/WH; and retailer stores and sites. These were documented through the research instrument, notes and photographs. Furthermore, the usage of space in manufacturer warehouses, DC/WHs and retailer stores were classified into the following descriptors: floor, cubic and pallet utilisation. These were assessed through observation using the rating scale of 90%(Full), 75%(¾) , 50%(½) and 25%(½) for the various descriptors.

4.9.2.2 Measurements

The data on the logistics operations; order processes; the activities in the manufacturing company warehouses; activities in distribution centres/warehouses; and operations in transportation sub-systems were generated by physical on-site measurements. This was done with the aid of measuring instruments, such as a measuring tape, stopwatch, wrist watch and a clock.

The data collected included the following:

- measurement of the size of manufacturer warehouses;
- DC/WH;
- retailer stores;
- the loading area;
- the measurement of time taken to load and offload;
- internal order cycle time;
- transit time;
- quantity of materials processed per order; and,
- Distance of shipment.

In addition, the number of staff used for order processing; quantity of material loaded/ offloaded; number of labourers used; the cost of loading/offloading each vehicle and the quantity of fuel consumed per distance of shipment was recorded. Furthermore, records were kept on the level of automation and technology used in warehouses. Google map was used to generate road distances between the manufacturer plants and DC/WHs, retailer stores and construction sites.

4.10 The Population and Sample of the Research Study

The research population is an entire set of people or substances that have some shared and discrete features, in line with the sampling conditions recognised by the researcher (Cassim, 2014:73). The population of this research comprised all the construction material manufacturers within the six geo-political zones of Nigeria. The process of sampling in primary data collection involves the following stages: defining the target population, choosing the sampling frame, determining the sampling size and selecting a sample method. The next section briefly discusses these stages.

4.10.1 Target Population

The target population signifies a broader population that is best suited to provide the primary data being sourced for the research. The target population of this research comprised all the construction material manufacturers within North-Central Nigeria.

4.10.2 Sampling Frame

The sampling frame can be described as a list of persons inside the target population who can contribute to the research (Dudovskiy, 2016:8). The sampling frame of this research comprised of all the listed of construction material manufacturers of cement; steel reinforcement; ceramic tiles; crushed stones; hollow sandcrete block and extractors of sand within North-Central Nigeria.

4.10.3 Sampling Size

The sampling size is the number of individuals from the sampling frame who were utilised as part of the primary data collection process (Dudovskiy, 2016:8). The decision on the sampling size is influenced by consideration of the scope and depth required (Fellow and Liu, 1999:143). Additional practical reflection indicated that to get significant data, one should monitor the greatest number of sites available during the research effort.

The research sample size was ten construction material manufacturers. They produced and distributed their products within five state capitals, and in Abuja, which is in North-Central Nigeria. These carefully chosen sites needed to be logistically, instead of statistically, significant in the population (Shakantu and Emuze, 2012:668). In this way, the sample of sites required to be selected would be those that would give adequate logistics operations and processes for analysis within a reasonable time.

4.10.4 Sampling Method

Sampling approaches are usually classified into two groups: Probability and Non-probability. In Probability Sampling, every member of the population sample has a known probability of taking part in the study. Probability Sampling methods include simple, stratified, systematic, multistage and cluster methods (Dudovskiy, 2016:8). Non-probability Sampling occurs when persons are selected in a non-random way,

therefore not every member of the population has the possibility of taking part in the study. Non-probability Sampling methods comprise purposive, quota, convenience and snowball methods (Dudovskiy, 2016:8).

The purposive sampling technique is adopted for the selection of cases that are especially informative subjects or units of observation, and that are representative of the wider phenomenon being studied. Saunders, Lewis and Thornhill (2009:172) and Leedy and Ormrod (2013: 221) stress that purposive sampling ensures that the scholar selects persons or other components, as the name suggests, for a particular reason. The purposive sampling technique was used for this study because it justifies the use of a few selected companies that would give adequate logistics operations and processes for analysis within a reasonable time. It was also the most appropriate method for the in-depth field study.

4.11 Analysis of the Data

Data analysis is the orderly coordination of the raw data into a meaningful form. This includes examining, classifying, transforming and modelling the data (Babbie, 2007: 378). For this study, descriptive analysis of the data was employed.

4.11.1 Descriptive Analysis

As confirmed by Lind, Marchal and Wathen,(2008:142), scholars can apply a number of descriptive statistic techniques to describe data. These include frequency distributions or cumulative frequency distributions, frequency polygons, various kinds of charts (histograms, bar charts, pie charts), scatter diagrams and box plots.

The descriptive analysis adopted in this study was supported by Loeb, Dynarski, McFarland, Morris, Reardon and Reber (2017:8), who stated that there are times when a descriptive investigation can stand alone. This is particularly true when a study's results focus on understanding unrecorded phenomena or identifying real-world requirements that allow guidelines or interventions. This kind of descriptive analysis can be informative when there is limited essential knowledge and understanding of a phenomenon (Loeb *et al.*, 2017:8). The descriptive tools used in this research include; bar-charts, pie-charts, frequencies and percentages. Observations made can be

presented with the aid of bar charts, while pictures can be presented as figures and interpreted directly.

4.11.2 Validity and Reliability of the Data

Validity is defined as the extent to which a test measures what it is intended to measure (Cooper and Schindler, 2013:176). Validity is often defined as the extent to which an instrument measures what it purports to measure. Leedy and Ormrod (2013:234) explain that validity, as a measurement instrument, is the extent to which an instrument measures what it intended to measure. Welman, Kruger and Mitchell, (2005:142) further explain that validity is the extent to which the researcher's findings accurately represent what really happened in the observed situation. Welman, Kruger and Mitchell, (2005:142) go on further to explain that an effect or test is valid if it demonstrates or measures what the researcher thinks or claims it does. Research errors, such as faulty research procedures, poor samples, and inaccurate or misleading measurements, can undermine validity.

Oliver (2010:176) considers validity to be a compulsory condition for a wide range of studies. There are various methods of research validity and popular ones are acknowledged by Cohen, Manion, Morrison and Morrison (2007:96) as content validity, criterion-related validity, construct validity, internal validity, external validity, concurrent validity and face validity.

Reliability is the extent to which the measurement scale is free of random unstable error, that is the extent of dependability, consistency and stability in its measurement result. The data, its treatment and interpretation must be based on its reliability. The same results should be consistently reached through different tests to ensure reliability. Wilson (2010:134) commented that consistency issues are often solidly associated with prejudice, and once a researcher espouses a subjective strategy towards the study, at that point the level of reliability of the work would be compromised. In this study, a more universal understanding of patterns within a population of interest was sought (Loeb *et al.*, 2017:2).

The internal validity of the study was based on the measurement of internal order cycle time, level of information technology and automation adopted in the processing of

information flow and material handling at the warehouses. The dynamics of material delivery validity included the measurement of distance travelled, transit time, vehicle capacity, loading state of vehicle on arrival and on departure, vehicle waiting time at the terminal, method of loading and offloading, loading and offloading time, and the cost of transport. Besides, the credibility of observations was improved by the researcher communicating directly with personnel involved in Management-CMLS. Furthermore, the field study took place in an environment (standard manufacturer warehouse processes and transportation operations) not designed by the researcher and had the advantage of a natural real-world view.

4.12 Ethical Considerations

Moral issues in research are concerned about protection, consent, confidentiality, dishonesty and avoiding mistreatment to those who participated in the research (Morton and Wilkinson, 2008:43). They are the benchmarks that differentiate between right and wrong conduct in research (David and Resnik, 2011:1). Moreover, privacy and anonymity of participants are crucial moral considerations in a research study (Blumberg, Cooper and Schindler, 2011:114). Consequently, this study was conducted with the following ethical concerns in mind:

Plagiarism: The research acknowledges the work of others used as material in the study. All sources of information were identified and appropriately referenced.

Confidentiality and anonymity: The individual rights to confidentiality and privacy are protected in this research. Responses/data generated from the field work on Management-CMLS were treated with absolute confidentiality and used for academic research purposes only.

Compliance with law and standards: The study does not contravene the research rules and regulations of the Nelson Mandela University.

Honesty and trust: The study reported on the data, methods and results as they are, without fabrication or misrepresentation.

Integrity: The research was conducted with sincerity, striving for consistency of thought and action.

Informed consent: The consent of the participants, (Marketing/sales managers, Logistics managers, Warehouse managers, Drivers and other employees), in this study was duly obtained.

4.13 Chapter Summary

Chapter 4 discussed the research philosophy, paradigm, reasoning approach and the method of investigation adopted for this study. It presented details on the kind of data collected; the research population, sample and sources of the data; and the data collection methods. Chapter 5 focuses on how this data was analysed and interpreted.

Chapter 5: The Data Presentation, Results and Interpretation

5.1 Introduction

Chapter 5 discusses the results of the field investigation of Management-CMLS. It presents the level of management efficiency and effectiveness as demonstrated by the Nigerian construction material manufacturers. Chapter 5 is divided into three parts:

Section 5.1 Introduction and Research Procedures

Section 5.2 Individual Company Case Studies

Section 5.3 Results of the Combined Studies for Sites 1-10

The nature of the research problem demanded capturing the order processing of construction material in and out of the of the manufacturing company plants/ warehouses, in line with the nodes and links concept view of a logistics system (Coyle, Bardi and Langley, 2003:146). By using the node and link concept, the volume of delivery vehicles entering and departing from the manufacturers' plant/ warehouse was measured. These included vehicles returning products. In addition, order cycle time, warehouse space utilisation, types and level of technology /automation used in processing information and handling of materials in the warehouses, were assessed. See Section 4.7.4 for a complete description of the processes involved.

5.1.1 Research Procedures

The construction material manufacturers selected as case studies were chosen on their size and type similarity, thus lending homogeneity to the sample. The technology they used, and mechanisation of their logistics processes also had to be closely identical throughout at the 10 Sites. The process adopted was as follows:

- The research instrument was first developed. A pilot study was then conducted at a company which manufactures clay bricks and paint. It is situated in North-Central Nigeria.
- The research instrument was modified after the pilot study to enrich its effectiveness and improve the speed required to capture data.
- During 15th to 22nd December 2016 and 5th to 12th January 2017, an exploratory tour of North-Central Nigeria was done to identify companies which manufacture the six selected materials: cement, reinforcement bars,

ceramic tiles, crushed stones, hollow sandcrete blocks and sand. A total of eight companies were identified as manufacturers of cement, reinforcement bars, ceramic tiles, crushed stones (two companies for each material). Their products were produced within and distributed across the six states of North-Central Nigeria and the Federal Capital Territory, Abuja.

- Twelve companies which produced hollow sandcrete blocks and twelve companies producing sand were identified (two in each of the six locations). Sandcrete blocks and sand are produced and distributed within their respective states and in Abuja. The summary of the total companies selected is presented in Table 5.1.
- During 13th to 22nd January 2017, a letter was sent to each case study company requesting permission to conduct research on their Management-CMLS. In each case a response from the management of the company, granting approval to conduct research was received before the field survey was conducted.
- During 24th January to 14th May 2017, the researcher collected data from the thirty-two Sites in random order, time and day. The non-participant structured observations of logistics processes were conducted across the various sections of the companies, namely marketing/sales, packaging, warehouse, logistics/transport and loading bays.
- The observations were made until there was a minimum of six customer orders, one each from the five states and Abuja. These orders from each Site were processed and delivered to the respective state capitals and Abuja. Notes on a total of seventy-two (72) observations were recorded to be representative of vehicle deliveries from the manufacturer's plant to DC/WHs, retailer stores and construction Sites. This is summarised in Table 5.1.

The lowest number of observations on any phenomena, which is statistically significant and could lead to the generalisable explanation of a phenomena, is 30 (Shakantu, 2005: 168). In this study, 72 observations were recorded, 42 more than 30 and therefore, more representative. Additional observations included the following:

- Observation were recorded on order cycle time, warehouse space utilisation, types of and level of technology /automation used in the processing of information, and the handling of material in the warehouses.
- The records of each company's DC/WHs and retailers, weekly demands/supplies, company vehicles used for delivery, delivery notes and prices of products were provided to the researcher. These data were then entered into Microsoft Excel for ease of statistical calculations required to generate patterns in support of, or against, the stated research objectives.

Table 5.1: Summary of Data Recorded

Materials	No. of Manufacturing Companies	Transportation (No. of Deliveries)	Location No. of DC/WHs and Retailer Shops							Construction Sites
			Abuja	Minna	Lafia	Lokoja	Jos	Makurdi	DC/ Warehouse	Sites
Cement	2	12	2	2	2	2	2	2	12	
Reinforcement bars	2	12	2	2	2	2	2	2	12	
Ceramic tiles	2	12	2	2	2	2	2	2	12	
Crushed stone	2	12	2	2	2	2	2	2	6	6
Hollow Sandcrete blocks	12	12	2	2	2	2	2	2	-	12
Sand	12	12	2	2	2	2	2	2	-	12
Total	**32**	**72**	**12**	**12**	**12**	**12**	**12**	**12**	**42**	**30**

Source: Researchers' Field Survey (2019)

5.1.2 Analysis of data and Results

The analysis was done using percentage. A percentage is calculated by dividing the number of times a value for a variable is observed, by the total number of observations in the population, then multiplying this number by 100. The result is then presented in the form of bar charts and pie charts which represent the proportional value of the variable. Pictures were presented as figures and interpreted directly. The results of analyses of the individual company case studies are presented in the next section.

5.2 Individual Company Case Studies

The descriptors of each individual case study are presented, starting with an overview of the manufacturing company and identifying the logistics channels, location and number of DC/WH. This includes the methods of packaging material, methods of storage, space usage in warehouses, vehicle ownership and methods of loading and offloading of material at the terminals. Tables, figures, pie charts, bar charts and pictures are used to present the data.

Table 5.2 shows the case study Sites surveyed. The data collection comprised Case Studies 1 to 10 and Manufacturing Company (MFC) Sites 1 to 10.

Table 5.2: Case Study Site Areas

S/No	Type of Manufacturers		Case Studies	MFC Sites
1	Cement		Case study 1	MFC Site 1
2	Cement		Case study 2	MFC Site 2
3	Steel (Reinforcement bars)		Case study 3	MFC Site 3
4	Steel (Reinforcement bars)		Case study 4	MFC Site 4
5	Ceramic tiles		Case study 5	MFC Site 5
6	Ceramic tiles		Case study 6	MFC Site 6
7	Crushed stones		Case study 7	MFC Site 7
8	Crushed stones		Case study 8	MFC Site 8
9	Hollow sandcrete block		Case study 9	MFC Site 9-20
10	Sand		Case study 10	MFC Site 21-32

Source: Researcher's Construct (2019)

5.2.1 Case Study 1- MFC Site 1

5.2.1.1 Case Study 1: MFC Site 1 - Overview

The MFC Site 1 Plant, a cement plant has a capacity of 10-25 Metric Tonnes Per Annum (MTPA). The plant is energy efficient due to the vertical roller mills used for the grinding of clinker and raw material. The average capacity utilisation rate at the plant stands at 80% on a nation-wide distribution platform. The company enjoys an extensive distribution network, allowing it to easily distribute its cement farther inland. It has strategically located depots and warehouses across Nigeria. The sale and distribution of cement is coordinated by four departments namely, sales/marketing, logistics, packaging and transport. It is well poised to continue its greater reach into various regional markets and to extend its dominance into the northern region market.

5.2.1.2 Case Study 1: Logistics Channels Utilised by MFC Site 1

Several logistics procedures are conducted in logistics channels. This study determines the logistics channels used by the company's manufacturing construction material.

In terms of the classification of logistics channels, Figure 5.1 presents the three alternative logistical channels used by MFC Site 1 for shipment of construction materials from the manufacturer warehouse to customers within North Central Nigeria. The three channels are: Direct- to-end-user, Direct to retailer-end-user and Distribution Centres/warehouses. The Direct- to- end -user is also known as direct sales strategy and has the advantage of removing middle men and reducing the lead time. This reveals that multiple channels are being used by MFC Site 1.

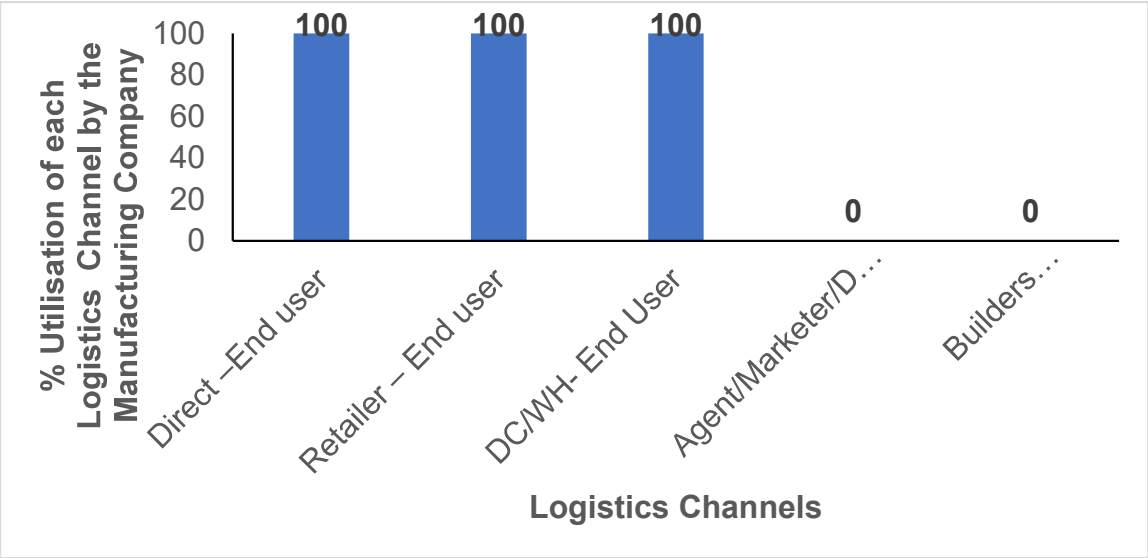

Figure 5.1: Logistics Channels utilised by MFC Site 1
Source: Researcher's Field Survey (2019)

5.2.1.3 Case Study 1: Location and Number of DC/WHs Utilised by MFC Site 1

Archival records were collected on the number of distribution centres/ warehouses and their location. The geographical spread of the DC/WHs is presented in Figure 5.2. The highest number of DC /WHs is at Abuja, being 31%. At least 17% each are in Jos, Minna and Makurdi.

In addition to transportation costs, companies determined their DC/WH locations based on major markets and customers, the level of service required and the product characteristics. This supports the finding that Abuja has the highest concentration of DC/WHs.

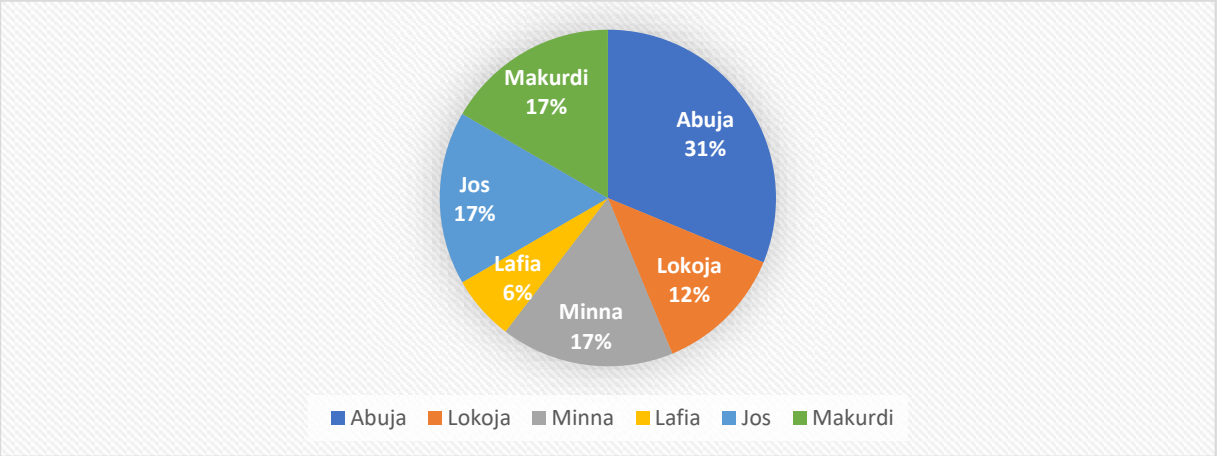

Figure 5.2: Location and Number of DC/WHs
Source: Researcher's Field Survey (2019)

5.2.1.4 Case Study 1: Method of Packaging of Materials Utilised by MFC Site 1

Packaging of material plays a dual role: to protect the product from damage and to make it easier to store, handle and transport - thereby lowering logistics costs. Figure 5.3 indicates that a bag was used for the packaging of 50kg of cement. However, bulk special orders for construction can also be moved in silo trucks (30-45 tons), and jumbo bags (1.5kg-20 No = 30tons). But the packaging is not recycled, meaning that the issue of sustainability is not properly addressed.

At the packaging plant, a Roto packaging machine was used to package the cement from the silos into bags of 50kg each. The machine output is 180 tons per hour (3600bags/hr.). The bagged cement is moved on a conveyor belt to an automatic loader at the loading bay.

Figure 5.3: Method of Packaging Cement Using the Roto Packaging Machine
Source: Researcher's Field Survey (2019)

5.2.1.5 Case Study 1: Method of Storage and Space Utilisation by MFC Site 1

Once the production process is completed, the bulk products were stored in silos. The company has 4No silos of 10,000 tons capacity each. The product moves from silos to the Roto packaging machine, where it is bagged and carried on a conveyor belt to the automatic loader. Vehicles are then loaded and dispatched. There is no warehouse, hence no storage of packaged material is needed. This process reduced multiple handling as it is fully automated and inventory management was clearly minimised.

Warehouse utilisation is normally measured in the amount of floor space. However, it is more realistic to measure the cubic utilisation of the whole building. Moreover, storage in racks is a very cost-effective measure of increasing the volume of goods in

each floor space. Therefore, the usage of space in manufacturer warehouses, DC/WHs and retailer stores were classified into the following descriptors: floor, cubic and pallet utilisation. These were assessed through observation using the rating scale of 90%(Full), 75%(¾) , 50%(½) and 25%(½) for the various descriptors.

The MFC Site 1 operated on zero inventory - it does not have warehouses. Therefore, space utilisation in the manufacturer warehouse could not be assessed. However, Figure 5.4 shows a 90% floor space and 75% of cube method of storage of cement in a typical distributor's warehouse. The floor and cube method space were used efficiently in the warehouse.

Figure 5.4: Cube Method of Storage and Space utilisation in a DC/WH
Source: Researcher's Field Survey (2019)

5.2.1.6 Case Study 1: Vehicle Ownership by MFC Site 1

Data of vehicles used for the delivery of cement from MFC Site 1 to the DC/WHs was analysed based on ownership and is presented in Figure 5.5. It shows ownership by manufacturers (50%), distributors/wholesalers (33%) and a third party (17%). In addition, the records from the transport department of MFC Site 1 established that it owns a total of 2252 trailer trucks. These are vehicles used to dispatch material to various depots, distribution centres, warehouses and direct sales to customers across the six regions of the country. The trucks are of various capacities: 40-ton trucks carry 800 bags per trip; 45-ton trucks carry 900 bags per trip, and 55-ton trucks carry 1100 bags per trip.

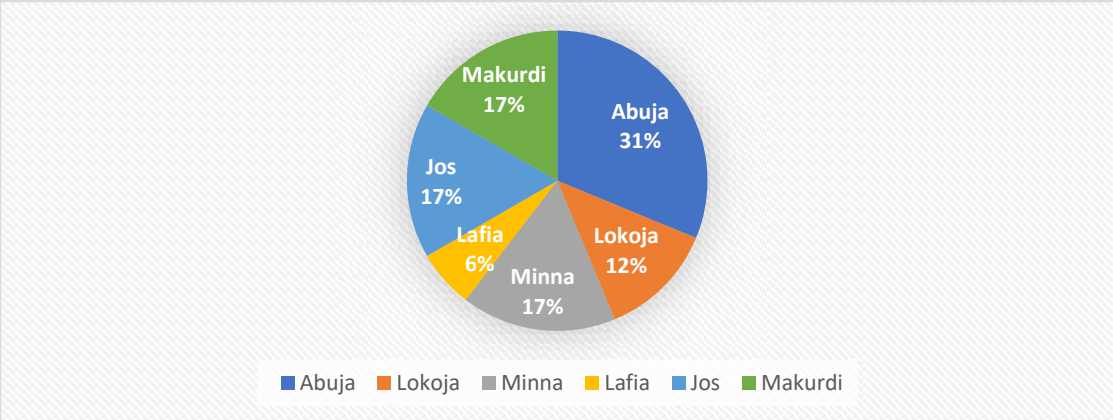

Figure 5.5: Vehicle Ownership
Source: Researcher's Field Survey (2019)

5.2.1.7 Case Study 1: Method of Loading Cement at MFC Site 1

Figures 5.6, 5.7 and 5.8 show that the company uses an automated loading method. The company has four Roto packaging machines, and each is connected to an automatic loader via a conveyor belt. Three automatic loading machines load at a time, while one is on standby. Two operators monitor each machine. A total of twelve trucks can be loaded at a time. Loading is done 24 hours per day.

The processes involved start once an Authority to Collect (ATC) is issued by the Sales Department, permitting the vehicle to move to the loading bay. At the entrance gate is a weighing bridge. First, the weight of the empty truck is taken. The truck is then moved out of the bridge. It is given an outbound delivery note with an order reference. Thereafter, the truck is moved to the loading bay.

The automatic loader loads the trucks in layers of 10 bags, interlocking them for stability. It takes an average of 35-40 minutes to load a truck. The process here was a completely automated system. After loading, the vehicle is moved to the weighing bridge at the gate for a second gross weighing. The first weight reading is subtracted from the second weight reading to determine the net weight of the cement loaded onto the truck. If there is no discrepancy between the net weight and the quantity ordered, then the vehicle will be allowed to leave. However, if there is any shortage or excess, then the truck is moved back to the packaging plant for adjustment of the quantities.

Figure 5.6 Packaging Bags

Figure 5.7: Bag of Cement on Conveyor Belt

Figure 5.8: Automatic Loader

Source: Researcher's Field Survey (2019)

5.2.1.8 Comments/summary analysis Case Study 1: MFC Site 1

The table 5.3 presents comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.3: Summary of Analysis of MFC Site 1

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	3no Channels Direct-to-end user Direct-to-Retailers -End user Direct-to-DC/WH- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja one third of total no Minna, Jos and Makurdi have equal no	Fair spread across state
3	Method of packaging	Packaging material- Bags, silo trucks	No reusable inefficient
		Packaging method – Automated	Efficient
4	Vehicle Ownership	Manufacturer in house -	Inefficient
		Distributors/Retailers -	Inefficient
		Third Party (Outsourcing) -	Inefficient
5	Method of Loading	Manufacturers warehouse- Automated loading	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites- Manual	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	Zero inventory- Efficient
		DC/WH/Retailer stores and sites- Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Construct (2019)

5.2.2 Case Study 2: MFC Site 2

5.2.2.1 Case Study 2: MFC Site 2 - Overview

The MFC Site 2 Plant, a cement plant, has a production capacity of 3 Metric Tonnes Per Annum (MTPA). However, unlike the MFC Site 1 plant, it runs primarily on the more expensive Low Pour Fuel Oil (LPFO), hence it is riddled with increased costs that result in lower margins. The operational policy of the company includes a direct sales strategy that is gaining popularity and has launched a 3x brand of 42.5R cement which sets quicker. The direct sales now comprise more than half of the dispatches. The company's investment rationale can be summarised as demonstrating cost efficiency from having a modern efficient plant. Like the MFC Site 1, the sale and distribution of cement is being coordinated by four departments, namely sales/marketing, logistics, packaging and transport.

5.2.2.2 Case Study 2: Logistics Channels utilised by MFC Site 2

The logistics channels utilised by MFC Site 2 are presented in Figure 5.9, and like those in MFC Site 1 discussed in Section 5.2.1. However, Direct Sales to retailers and the end–user form more than half of their dispatches now. In the Direct Sales strategy process (push strategy), vehicles are loaded and driven to various state capitals. The drivers now contact their distributors or retailers, in case they may want to buy the products. They may also look for any other buyers. Any prospective buyer who can afford to pay will be given the company's account number and Sales Manager's phone number by the driver. Once the customer has confirmed the cost of the product from the Sales Manager by phone, he/she pays the amount into the company's bank account. Immediately payment is made, the Sales Manager receives a credit alert and confirmation from the bank. The Sales Manager then directs the driver to deliver and offload the material to the customer. The condition for this sales transaction is that the minimum order quantity must be a truck load, which limits affordability to individual customers. This suggests a great reduction in lead time.

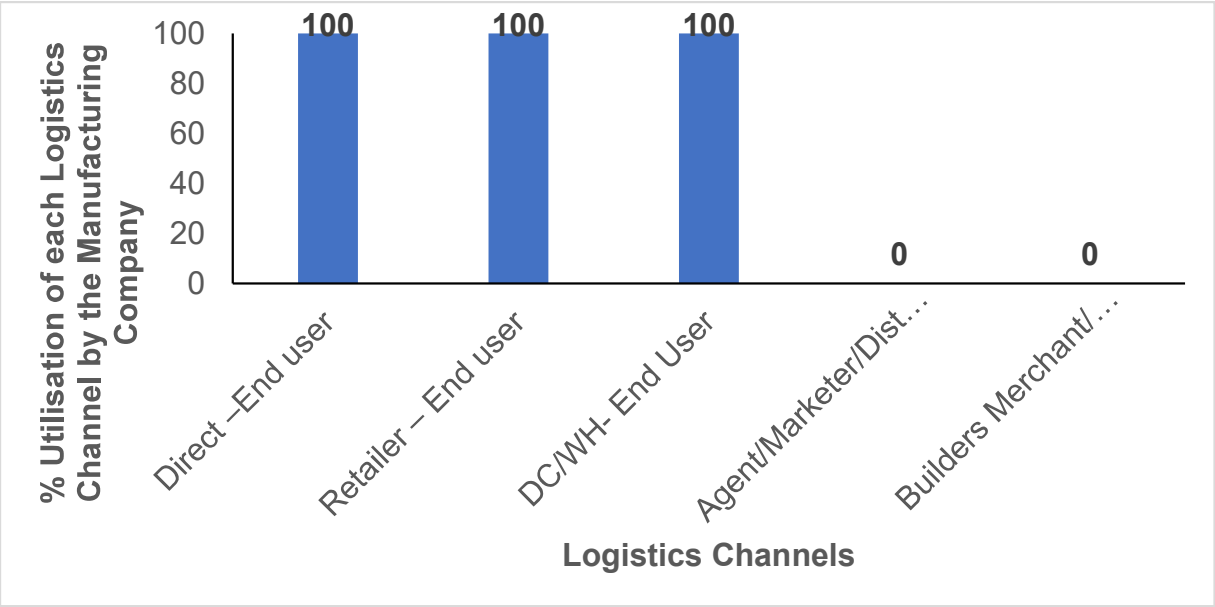

Figure 5.9: Logistics Channels utilised by MFC Site 2
Source: Researcher's Field Survey (2019)

5.2.2.3 Case Study 2: Location and Number of DC/WHs Utilised by MFC Site 2

The archival records of the company's distribution centres/warehouses and retailer stores, and their locations, were obtained from their sales department. Figure 5.10 distributes these as follows: Abuja (35%), Minna (17%) and Jos (15%). Figure 5.10 further shows that there is a higher concentration of DC/WHs in Abuja. This might be due to the high volume of construction work in Abuja.

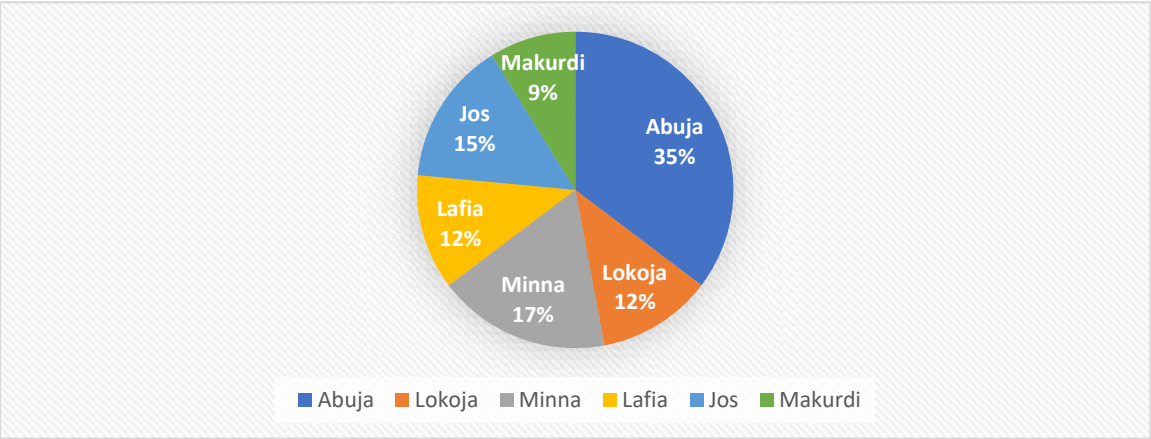

Figure 5.10: Location and Number of Distribution Centres /Warehouses
Source: Researcher's Field Survey (2019)

5.2.2.4 Case Study 2: Method of Packaging of Materials Utilised by MFC Site 2

The packaging method at this Site is like MFC Site 1 discussed in Section 5.2.1.4 Figures 5.11, 5.12 and 5.13 show typical material transport section linking silos to roto packer, the Roto packer machine and Packaged cement on Conveyor belt to automatic loading machine. The normal package of 50kg per bag is not transported using a pallet, thus leading to multiple handling actions during offloading. The implication is an increase in offloading cost and time.

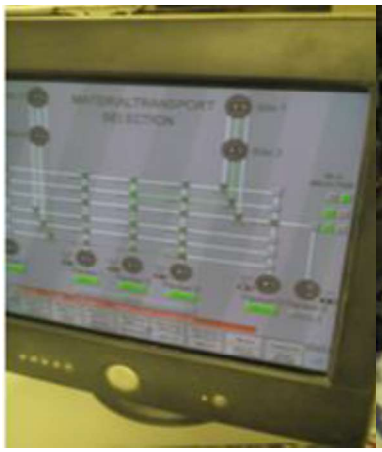

Figure 5.11: Material Transport Section

Figure 5.12: Rotor Parker Machine

Figure 5.13: Packaged Cement on Conveyor Belt

Source: Researcher's Field Survey (2019)

5.2.2.5 Case Study 2: Method of Storage and Space Utilisation by MFC Site 2

The MFC Site 2 also does not have a warehouse but operates like MFC Site 1 described in Section 5.2.1.5. Figure 5.14 presents the typical floor and cube method of space utilisation in a retailer's shop. In this case, both the floor and cube of the building indicate a trade-off, showing that space utilisation is optimised.

Figure 5.14: Cube Method of Storage in Retailer Store
Source: Researcher's Field Survey (2019)

5.2.2.6 Case Study 2: Vehicle Ownership by MFC Site 2

The analysis of the ownership of vehicles used for the delivery of cement from the MFC Site 2 plant to various DC/WHs and retailer stores is presented in Figure 5.15. It reveals ownership as by manufacturers (34%), distributor/wholesalers (33%) and third parties (33%). The MFC Site 2 has a fleet of 1552 vehicles (trailers) for the delivery of products to customers.

The practice is that a customer pays for the material, including delivery or self-collection, which means that the customer bears the cost of transportation. In the case of company delivery, the Sales Department manager confirms an ATC with the customer's name and sends this to the Transport Department, where a truck is arranged to deliver the material. But, in the case of self-collection, the Sales/Marketing Department issues an ATC with the customer's name, driver's name and the vehicle number. This ATC document is used as a gate pass to the loading bay. However, if there is high demand, then the Transport Department prepares a schedule of delivery. Some of the vehicles are dedicated to direct deliveries to customers. Each vehicle has a tracker for monitoring delivery progress.

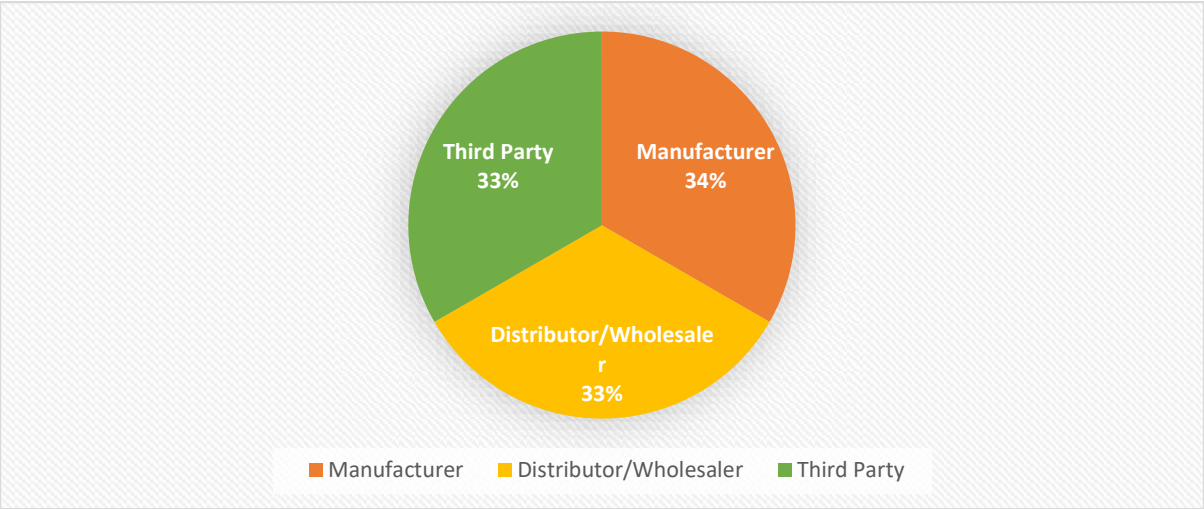

Figure 5.15: Vehicle Ownership
Source: Researcher's Field Survey (2019)

5.2.2.7 Case Study 2: Method of Loading and Offloading Cement at MFC Site 2

The automatic loading machine is used for loading cement into a vehicle at the loading bay. The process is like that at MFC Site 1. However, the confirmation of total tonnage carried by each truck and the weighing is done by representatives of four departments: Sales, Transport, Logistics and Security. It is important to note that the loading process at the manufacturer's warehouse is fully automated.

Figures 5.16 and 5.17 show the loading of a vehicle at the manufacturer's plant and a vehicle on a weighing bridge respectively. Figure 5.18 shows the manual offloading of cement at the wholesaler's warehouse and retailer shops.

Figure 5.16 Loading of Vehicles at Loading Bay

Figure 5.17 Vehicle on Weighing Bridge

Figure 5.18 Offloading Loading Bay

Source: Researcher's Field Survey (2019)

5.2.2.8 Comments/summary analysis Case Study 2: MFC Site 2

The table 5.4: presents comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.4: Summary of Analysis of MFC Site 2

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	3no Channels Direct-to-end user Direct-to-Retailers -End user Direct-to-DC/WH- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja one third of total nos Minna then followed and Makurdi Lafia and Lokoja have equal nos	Fair spread across state
3	Method of packaging	Packaging material- Bags, silo trucks	No reusable inefficient
		Packaging method – Automated	Efficient
4	Vehicle Ownership	Manufacturer in house -one third of the total no	Inefficient
		Distributors/Retailers - one third of the total no	Inefficient
		Third Party (Outsourcing) - one third of the total no	Inefficient
5	Method of Loading	Manufacturers warehouse- Automated loading	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites- Manual	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	Zero inventory- Efficient
		DC/WH/Retailer stores and sites- Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Construct (2019)

5.2.3 Case Study 3: MFC Site 3

5.2.3.1 Case Study 3: MFC Site 3 Overview

The MFC Site 3 Plant, it produces steel bars. It has the capacity to produce 550,000 tons of steel per annum. MFC Site 3 has the following Vision and Mission:

Vision: To aspire to be the leading supplier of a full range of quality steel products in the North-Central Region and a valued partner of all our stakeholders.

Mission: To achieve it, the company strives to:

i. Be the supplier of choice for customers by supplying a wide variety of high-quality steel products.
ii. Promote a culture of ethical conduct and excellence.
iii. Look after the welfare of our employees by providing a safe and rewarding working place.
iv. Conduct our business in a cost-efficient manner to ensure that stakeholders are appropriately rewarded.
v. Protect nature by creating a clean environment.

MFC Site 3 understands that its long-term growth is heavily dependent on its supply chain. The managers have partnered extensively with professionals within the supply chain to ensure that the highest level of quality is maintained from sourcing, procurement, conversion and logistics. It now boasts a distribution footprint across North-Central and other regions of the country, making them the reliable partner that industry needs for growth.

5.2.3.2 Case Study 3: Logistics Channels utilised by MFC Site 3

Figure 5.19 indicates the two logistics channels used by MFC Site 3 for processing customer orders. The two channels are: Direct-to-end-user and Agent/marketer-distributor/wholesaler-retailer-end-user were used for the delivery of products. The Direct-end-users has the potential to reduce lead time compared to the Agent/marketer-distributor/wholesaler-retailer-end-user channel. However, the minimum quantity that can be sold directly to an end-user is 30 tons. But, unlike MFC Site 1 and MFC Site 2, where products are delivered to customers in a direct strategy,

MFC Site 3 does not provide delivery service. Their customers arrange for their own deliveries.

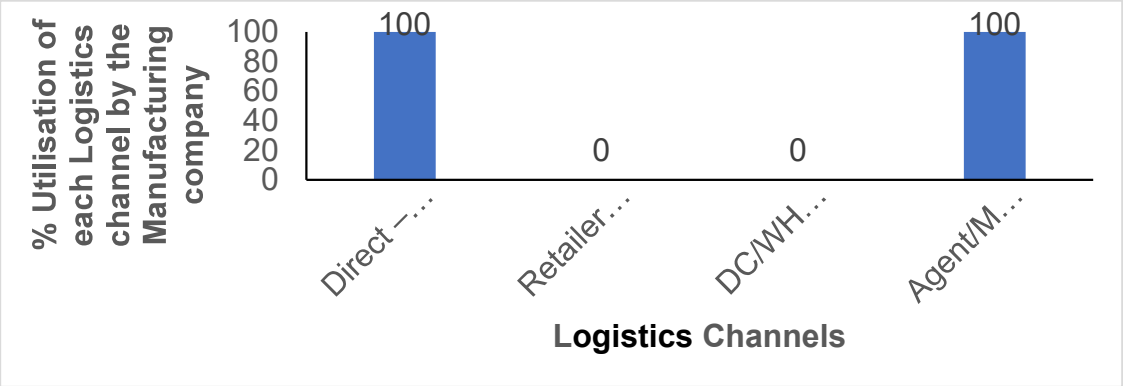

Figure 5.19: Logistics Channels utilised by MFC Site 3
Source: Researcher's Field Survey (2019)

5.2.3.3 Case Study 3: Location and Number of DC/WH and Retailer Stores by MFC Site 3

In a chart form, the location and number of DC/WHs and retailer stores are shown in Figure 5.20. The breakdown is as follows: Abuja (44%), Jos (13%), Minna (10%), Lafia (10%), Lokoja (10%) and Makurdi (10%). More DC/WHs were in Abuja, which may be due to the high demand in the area. The least number of DC/WHs was in Lafia, the Nasarawa State capital. This suggests a low market, or they may be getting their deliveries from other sources.

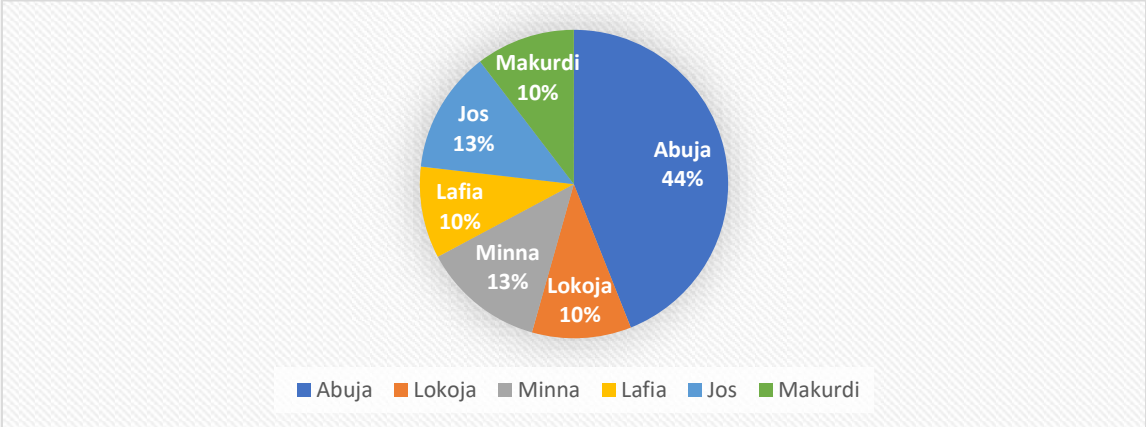

Figure 5.20: Location and Number of DC/WHs for MFC Site 3
Source: Researcher's Field Survey (2019)

5.2.3.4 Case Study 3: Method of Packaging Utilised by MFC Site 3

Figure 5.21 shows that the bundle method of packaging reinforcement steel bars was used by MFC Site 3. The reinforcement steel was wrapped in bundles of 10 tons, respective to their sizes. This was made for easy handling and transporting. However, the bundling was mechanically done. This signifies low manual effort on packaging in MFC Site 3.

Figure 5.21: Packaging of Reinforcement Bars Wrapped in Bundles
Source: Researcher's Field Survey (2019)

5.2.3.5 Method of Storage and Space Utilisation by MFC Site 3

The chart on Figure 5.22 indicates the storage method used for reinforcement bars. The double-deep rack storage was used. In this case, two bundles were stored per position and this provided greater cube utilisation than single-deep racks because more loads could be accessed from the same side of the rack.

In addition, The MFC Site 3 warehouse was assessed through observation using rating scale of 90%(Full), 75%(¾), 50%(½) and 25%(¼) for the various space descriptors as explained in section 5.2.1.5. Figure 5.22 reveals storage distribution as floor space (90%), cube method (90%) and building utilisation (75%). The floor space of 90% utilisation reveals that there is minimal floor space requirement and high-level cranes are used for movement of materials within the warehouse. There is a balance between the floor and cube method utilisation of space. However, Figure 23 shows a typical storage space in DC/WHs and retailer stores, where storage is usually done in open spaces.

Figure 5.22: Storage and Space utilisation in MFC Site 3 Warehouses

Source: Researcher's Field Survey (2019)

Figure 5.23: Storage and Space utilisation in DC/WHs and Retailer Stores

Source: Researcher's Field Survey (2019)

5.2.3.6 Case Study 3: Vehicle Ownership by MFC Site 3

The MFC Site 3 does not operate an in-house transport system. Customers are responsible for transportation of the material. Figure 5.24 shows the types of vehicles that owners used for transporting reinforcement bars. It reveals that MFC Site 3 used third party transport providers for all their deliveries. However, there are transport Vendors/ Agents who operate on commission to arrange transport for the shipment of material to customers. The MFC Site 3 enjoys the benefit of shifting their transport operations to the third-party transport provider Vendor/ Agents. However, the delay by the Vendor/ Agents in arranging for the delivery of materials may lead to an increase in lead time and cost.

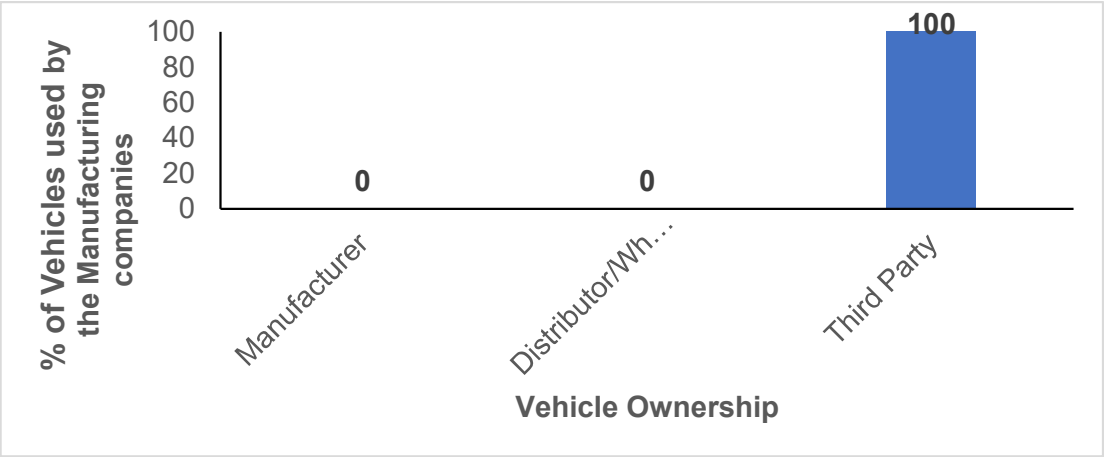

Figure 5.24: Vehicle Ownership Used for Delivery by MFC Site 3
Source: Researcher's Field Survey (2019).

5.2.3.7 Case Study 3: Method of Loading and Offloading Vehicles at MFC Site 3

Figure 5.25 presents the method of loading in MFC Site 3. It uses high level cranes to load material. This system uses a high-level crane to collect the bundles of steel reinforcement bars (wrapped in bundles of 10 tons) stored in double deep racking. The crane load clamp is used to move, or tilt bundled reinforcement bars. It then lifts the bundle up, moves it and places it on the vehicles. The crane can move horizontally and vertically simultaneously, thus reducing travel time between pick-up and put-down.

Figure 5.25 shows that material is offloaded manually at the other terminals. The process involves offloading, bending and stacking of the reinforcement bars, which is labour intensive, time consuming and costly.

Figure 5.25: Loading Vehicles Using High Level Cranes and Offloading Manually
Source: Researcher's Field Survey (2019)

5.2.3.8 Comments/summary analysis Case Study 3: MFC Site 3

The table 5.5 presents comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.5: Summary of Analysis of MFC Site 3

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	2no Channels Direct-to-end user Agent/marketer/distributor/wholesaler-retailer- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja about half of total nos and others fairly spread	Fair spread across state
3	Method of packaging	Packaging material- wrapping in bundles	Efficient
		Packaging method – Automated	Efficient
4	Vehicle Ownership	Manufacturer in house -None	Inefficient
		Distributors/Retailers - None	Inefficient
		Third Party (Outsourcing) - All	Inefficient
5	Method of Loading	Manufacturers warehouse-Automated loading	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites-Manual	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	Efficient
		DC/WH/Retailer stores and sites-Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Construct (2019)

5.2.4 Case Study 4: MFC Site 4

5.2.4.1 Case Study 4: MFC Site 4 Overview

MFC Site 4 Plant, is wholly an indigenous company which started its manufacturing operations in 1997. In 2014, the 150 000 MTPA capacity Cold Roll Steel Mill Complex was completed. It produces finished products for roofing, head pans, shovels, trowels and wire rods. These products include mild steel (MS) and high tensile (HT) ribbed bars from billets, plain bars and rebar. The standard length of rebars and twisted bars is 12 metres. Over a million bags of nails and 1.3 million tonnes of roofing sheets pour out of the MFC Site 4 factories to supply builders in Nigeria and West Africa.

The vision of the company is to be a leader in steel manufacturing and related services. They aim to earn their customers' loyalty through continuous improvement driven by the integrity, teamwork and innovation of their team. Their mission is to provide the highest-quality product to their customers; to guarantee their continued success; and to be an icon in the industry through individual and combined dedication, innovation and integrity. They give their employees opportunities for both personal and professional growth.

5.2.4.2 Case Study 4: Logistics Channels Utilised by MFC Site 4

Figure 5.26 indicates two logistics channels used for order processing of the steel reinforcement from the manufacturers production point to the end consumer. The two channels used were Direct-end-user and Agent/ distributor/ wholesaler- retailer-end-user. However, at MFC Site 4, a minimum order quantity is 30 tons through either of the two channels. The major finding is that two channels are used for the outbound logistics.

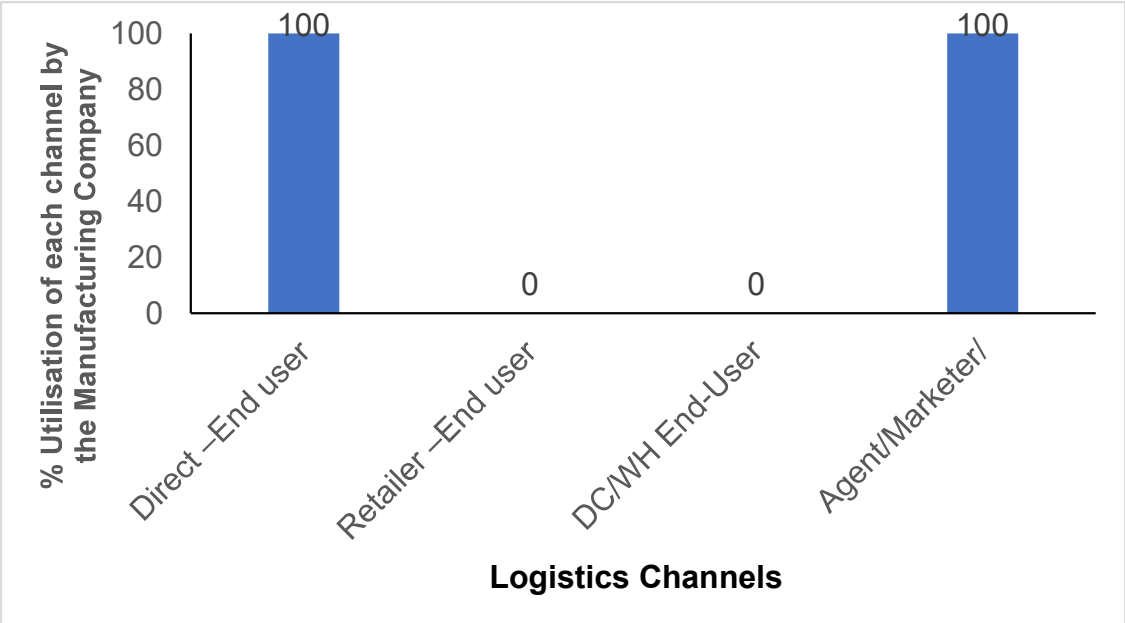

Figure 5.26: Logistics Channels utilised by MFC 4
Source: Researcher's Field Survey (2019)

5.2.4.3 Case Study 4: Location and Number of DC/WHs Utilised by MFC Site 4

Figure 5.27 presents the location and number of DC/WHs and retailer stores used by MFC Site 4. It revealed that the outlets were in Abuja (40%), Jos (18%) and Minna (15%). This reveals that most DC/WHs and retailers were in Abuja, which may be due to high demand in the area. The least number of DC/WHs were in Lafia, the Nasarawa capital, which suggests a low market, or they may be getting their delivery from another source.

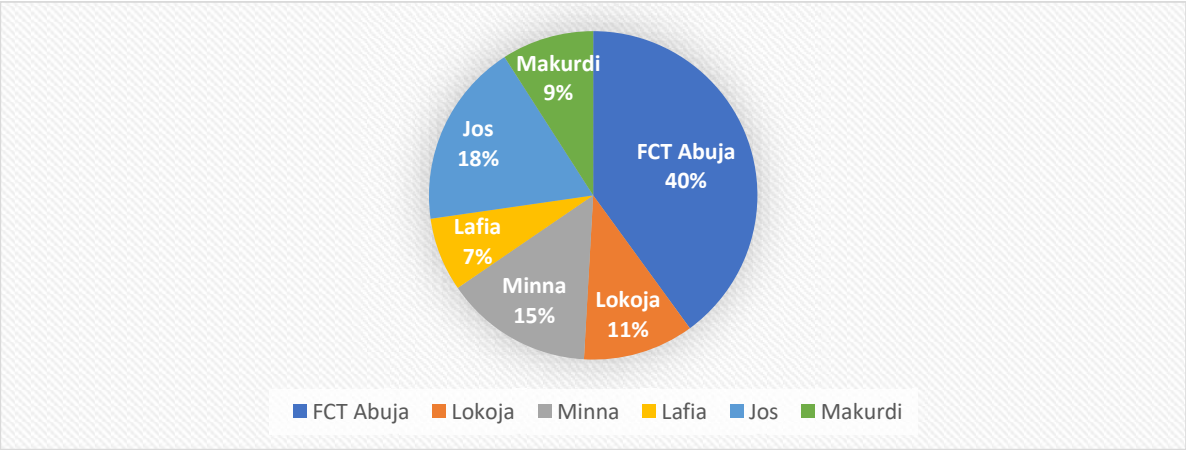

Figure 5.27: Location and Number of DC/WHs for MFC Site 4
Source: Researcher's Field Survey (2019)

5.2.4.4 Case Study 4: Method of Packaging for Material Utilised by MFC Site 4

Figure 5:28 illustrates the packaging steel reinforcement by bundle method.

Figure 5.28: Packaging - Reinforcement Bars Wrapped in Bundles in MFC Site 4 Warehouse
Source: Researcher's Field Survey (2019)

5.2.4.5 Case Study 4: Method of Warehouse Storage and Space Utilisation by MFC Site 4

Figure 5.29 reveals how double deep rack storage is utilised in the MFC Site 4 warehouse. This is like the MFC Site 3 warehouse.

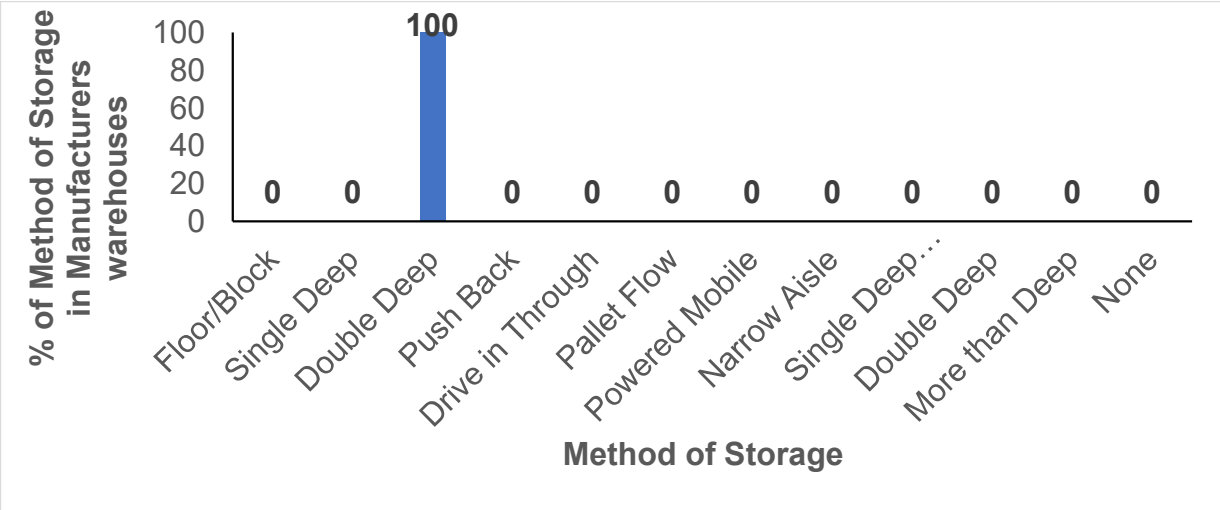

Figure 5.29: Method of Warehouse Storage in MFC Site 4
Source: Researcher's Field Survey (2019)

Figure 5.30 shows space utilisation in the MFC Site 4 warehouse. A total of 75% of the floor area was utilised, and 75% of the cube method of space utilisation was

observed. However, the building utilisation was 50% and pallet utilisation was, 0%. The major finding was the balance between floor and cube method space utilisation.

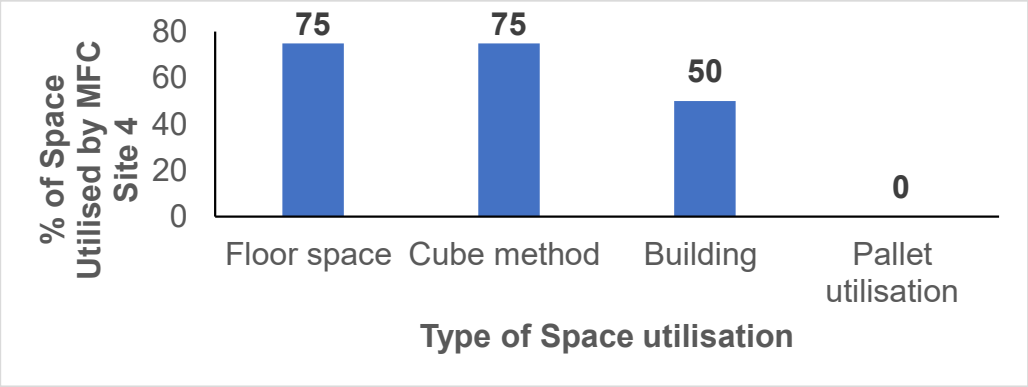

Figure 5.30: Warehouse Space utilisation in MFC Site 4
Source: Researcher's Field Survey (2019)

5.2.4.6 Case Study 4: Vehicle Ownership by MFC Site 4

Figure 5.31 indicates the type of ownership of vehicles used for delivery as follows: 67% were owned by third party transport providers and 33% by distributors/wholesalers. It is worth noting that MFC Site 4 does not own vehicles for delivering its products to customers. Customers were responsible for the transport of the material. This means that most of the vehicles used for the materials were owned by the third-party transport providers. The process of accessing a third-party transport provider was through a transport agent. The outsourcing of transport operations aims to increase enterprise competitiveness, reducing fixed operational costs and improving service level.

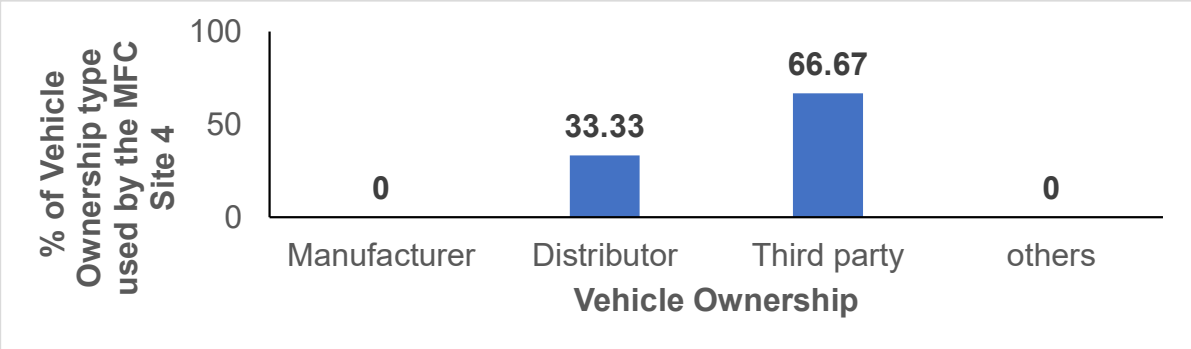

Figure 5.31 Vehicle Ownership Used for Delivery by MFC Site 4
Source: Researcher's Field Survey (2019)

5.2.4.7 Case Study 4: Method of Loading Vehicles at MFC Site 4

Figure 5.32 shows that the method of loading at MFC Site 4 is a high-level crane, which is the same as MFC Site 3.

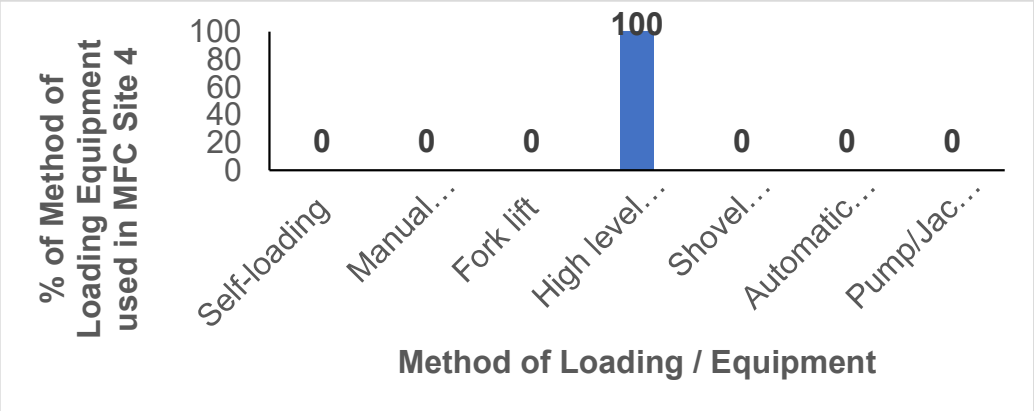

Figure 5.32: Method of Loading Vehicles at MFC Site 4
Source: Researcher's Field Survey (2019)

5.2.4.8 Comments/summary analysis Case Study 4: MFC Site 4

The table 5.6 presents comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.6: Summary of Analysis of MFC Site 4

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	2no Channels Direct-to-end user Agent/marketer/distributor/wholesaler-retailer- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja about half of total nos and others fairly spread	Fair spread across state
3	Method of packaging	Packaging material- wrapping in bundles	Efficient
		Packaging method – Automated	Efficient
4	Vehicle Ownership	Manufacturer in house -None	Inefficient
		Distributors/Retailers -One third	Inefficient
		Third Party (Outsourcing) – Two third	Inefficient
5	Method of Loading	Manufacturers warehouse- Automated loading	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites- Manual	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	Efficient
		DC/WH/Retailer stores and sites- Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Construct (2019)

5.2.5 Case Study 5: MFC Site 5

5.2.5.1 Case Study 5: MFC Site 5 - Overview

The MFC Site 5 plant, it produces ceramic floor tiles, wall tiles, porcelain vitrified tiles and royal roofing. Tiles are manufactured to international standard. The state-of-the-art production facility is fully automated and uses Italian technology and equipment. The dedicated in-house team of Italian and French designers ensure the production of the most modern and fashionable European designs. The company is devoted to bringing to customers the art of ceramic tiling by making it affordable, accessible and enjoyable.

Recently, the company has doubled its initial production capacity, thus enabling it to meet its consumer demand of polished and un-polished wall and floor tiles. The variety of porcelain vitrified tiles, ranges from soluble salt, glazed vitrified tiles, granite series, salt and pepper series, wood series, double charged to vitorsa tiles under the Vanadium Boride (VB) Series. Innovation is one of the MFC Site 5 core values. With a wide distribution network of 200 distributors and 2 depots across the country, it offers a wide presence for its consumers.

5.2.5.2 Case Study 5: Logistics Channels Utilised by MFC Site 5

Figure 5.33 presents three logistics channels for the delivery of ceramic tiles to the various locations in North-Central Nigeria. The three channels used were Direct-end-user, DC/WH and an Agent/marketer-distributor/wholesaler-retailer-end -user. The company operates a depot along Suleja-Kaduna Express Way. This suggests that the MFC Site 5 uses multiple channels to deliver products to customers. The benefits of each channel in the logistics operations had to be considered.

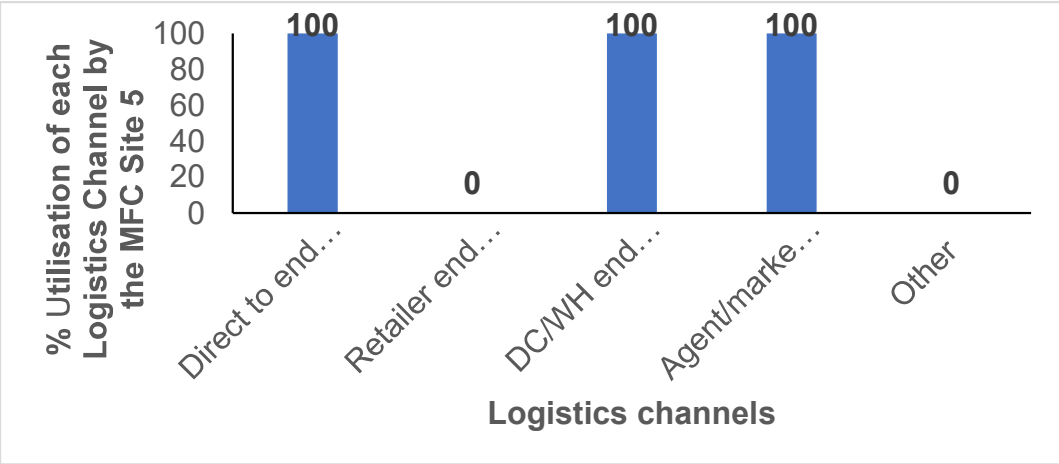

Figure 5.33: Logistics Channels utilised by MFC Site 5
Source: Researcher's Field Survey (2019).

5.2.5.3 Case Study 5: Location and Number of DC/WHs and Retailer Stores Utilised by MFC Site 5

Figure 5.34 indicates the locations and number of DC/WHs utilised by MFC Site 5 to distribute within the selected area. It reveals the following distribution: Abuja (38%); Minna (17%) and Lafia (7%). The high concentration of DC/WHs in Abuja suggests more customers and more demand for the products.

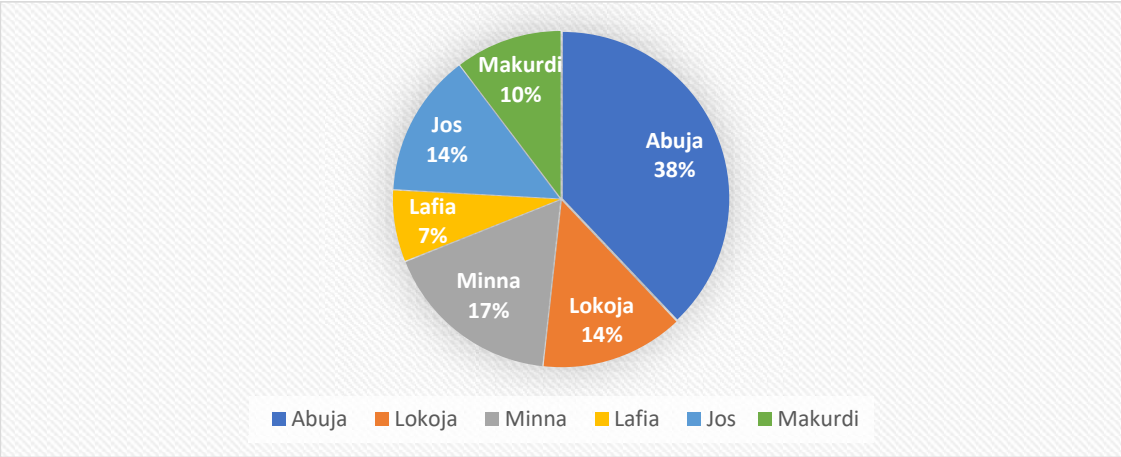

Figure 5.34: Location and Number of DC/WHs and Retailer Stores for MFC Site 5
Source: Researcher's Field Survey (2019).

5.2.5.4 Case Study 5: Method of Packaging of Materials Utilised by MFC Site 5

The packaging of ceramic products demands suitable methods and material and is a critical part of the manufacturing process. Even though packaging is frequently disposed of after the product arrives at the consumer's destination, it must protect the

material during transit. The packaging significantly influences a consumer's insight on its quality, because it is the first part of the product that they see. The weight and size of packaging impacts its shipping.

The materials used for packaging at the MFC Site 5 warehouse are as presented in Figure 5.36 and Figure 5.37, namely wooden pallets and cartons. The process of packaging is a semi-mechanised palletised, where operators manually wrapped tiles in cartons and arranged them in an interlocking manner on standard wooden pallets of size 1.2 x 1.2m. For stability and rigidity, the cartons are arranged in rolls of 4 packets horizontally, and 18, 20, 21, 27 columns vertically on each pallet, depending on their sizes. The fork lift truck moves the pallets to the storage area. This suggests multiple handling of material in the warehouse and is clearly labour intensive. Depending on the size of the tiles, the wrapping was done as follows:

300 x 600mm tiles – 8 pieces in packet = 1.44m^2

600 X 600mm tiles – 4 pieces in packet = 1.44m^2

400 x 400mm tiles – 12 pieces in packet = 1.92m^2

300 x 300mm tiles – 10 pieces in packet = 0.9m^2

250 x 400mm tiles – 10 pieces in packet = 1.0m^2

Figure 5:35: Tiles on Conveyor Belt

Figure 5.36: Wooden Standard Pallet

Figure 5.37: Cartons

Source: Researcher's Field Survey (2019)

5.2.5.5 Case Study 5: Method of Storage and Space utilisation by MFC Site 5

Figure 5.38 presents information on the method of storage equipment utilised in MFC Site 5 warehouses. A pallet flow rack is used. A pallet flow rack replenishment does

not interfere with picking. However, the process here suggests unit load storage, therefore making it easier and faster for picking. It also increases flexibility for the cube method space utilisation.

In addition, the space utilisation in MFC Site 5 warehouses showed that 75% of the floor area was utilised for storage. The remaining area was left for equipment and workers movement. The cube method utilisation showed that 90% was utilised. A total of 75% was observed for building utilisation. This suggests that there was a trade-off between the floor and cube-method on space utilisation.

Figure 5.39 shows a typical floor block storage in DC/WHs and retailer stores. No pallets were used, and the floor space utilisation was 90%, since no equipment or truck movement was required. Both floor and cube methods of space utilisation were maximised at 90%.

Figure 5.38: Pallet Floor Rack Storage Method used in MFC5 Warehouse
Source: Researcher's Field Survey (2019)

Figure 5.39: Floor/block Storage Method used in DC/WHs and Retailer Stores
Source: Researcher's Field Survey (2019)

5.2.5.6 Case Study 5: Vehicle Ownership by MFC Site 5

The analysis of the ownership of vehicles used for delivery of material from MFC Site 5 to DC/WHs and retailer stores is shown in Figure 5.40. It reveals that vehicles are owned by third party logistics providers (66%), manufacturers (17%) and distributors/ wholesalers (17%). The records show that the company operates a transport system with a fleet of 10 vehicles. However, the company's vehicles operate only between the plant warehouse and depot at Suleja. The customers must take responsibility to arrange trucks for their deliveries.

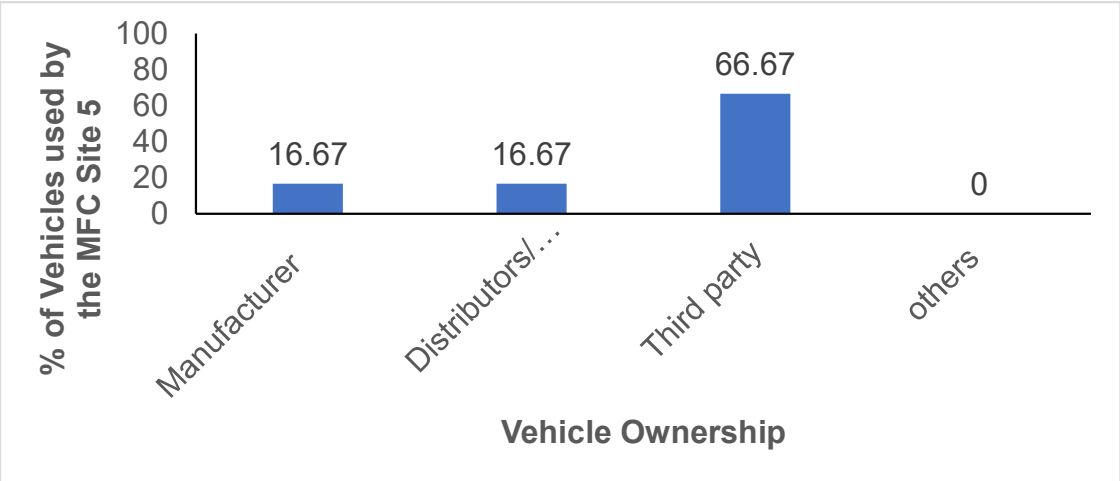

Figure 5.40: Vehicles Ownership Used for Delivery from MFC Site 5 Warehouse
Source: Researcher's Field Survey (2019)

5.2.5.7 Case Study 5: Method of Loading and Offloading Vehicles at MFC Site 5

Figure 5.41 reveals a combination of two methods: fork lift trucks and manual loading methods were used to load vehicles for shipment. The process of loading starts with the issuing of clearances, a gate pass with the name of the driver, transporter and destinations. Once it is signed by the Sales Manager and Chief Security Officer, the vehicle is allowed in and moved straight to the weighing bridge, where its weight is taken. Thereafter, it moves to the loading/dispatch area.

The loading bay is racked with a ramp. The driver reverses in for the vehicle to be packed. The forklift truck moves the pallet stacked with tiles onto the vehicle, and four-five workers remove the tiles from the pallet and arrange/ load them in to the vehicles. The process continues until the vehicles are fully loaded. The method of loading suggests multiple handling, which is labour intensive since the ceramic tiles are not

transported on the pallets. The offloading of tiles at the DC/WHs and retailer stores is done manually, as shown in Figure 5.42.

Figure 5.41: Forklift Truck and Manual Methods Used in Loading Vehicles at MFC Site 5
Source: Researcher's Field Survey (2019)

Figure 5.42: Manual Method of Offloading Vehicles in DC/WHs and Retailer Stores
Source: Researcher's Field Survey (2019)

5.2.5.8 Comments/summary analysis Case Study 5: MFC Site 5

The table 5.7 presents comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.7: Summary of Analysis of MFC Site 5

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	3no Channels Direct-to-end user Direct-DC/WH-end user Agent/marketer/distributor/wholesaler-retailer- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja one third of total nos and others fairly spread	Fair spread across state
3	Method of packaging	Packaging material- wooden pallet and carton	Efficient
		Packaging method – Semi-Automated (use fork lift truck and manual)	Efficient
4	Vehicle Ownership	Manufacturer in house -low use	Inefficient
		Distributors/Retailers -low use	Inefficient
		Third Party (Outsourcing) –mostly used	Inefficient
5	Method of Loading	Manufacturers warehouse- Semi-Automated loading (use fork lift truck and manual)	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites- Manual	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	Efficient
		DC/WH/Retailer stores and sites- Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Field Survey (2019)

5.2.6 Case Study 6: MFC Site 6

5.2.6.1 Case Study 6: MFC Site- Overview

MFC Site 6 Plant, is a leading manufacturer of ceramic and porcelain tiles in Nigeria. It has been serving the needs of the building material industry in Nigeria for decades. It presents a wide range of products in wall and floor tiles in both ceramic and porcelain polished categories.

The plants are fully automated and use German and Spanish technology. They offer an exquisite range of polished and un-polished ceramic wall and floor tiles. They produce a variety of porcelain tiles, for example, porcelain glossy tiles, porcelain polished series, marble series, wood series, cloud series and rustic series.

With a wide distribution network of 260 distributors and 2 depots across the country, the MFC Site 6 ceramics company offers easy availability of quality tiles for their consumers. MFC Site 6 have distributor-owned showrooms and experience centres located in Abuja, Lagos and Port Harcourt. These display a full range of products, thus helping customers to view and choose a product of their choice and taste.

5.2.6.2 Case Study 6: Logistics Channels Utilised by MFC Site 6

Figure 5.43 presents the two logistics channels used in MFC Site 6 for the delivery of finished ceramic tiles to customers. The two channels are: Direct-end- user and Agent/market-distributor/wholesaler-retailer-end-user. The minimum quantity that can be sold to a retailer is 30 tons, which is a full truck load. The Direct-end- user channel has the potential to reduce lead time. The minimum order quantity has great implication on customers' affordability. More so, the quantity may be more than an individual may need. The Agent/Market-Distributor/Wholesaler-retailer-end-user may have more intermediaries, so they may potentially increase the lead time compared to the direct-end-user channel.

Figure 5.43: Logistics Channels utilised by MFC Site 6
Source: Researcher's Field Survey (2019)

5.2.6.3 Case Study 6: Location and Number of DC/WHs and Retailer Stores Utilised by MFC Site 6

Figure 5.44 indicates the number of DC/WHs in each location for the distribution of the material within the study area. It reveals the following: Abuja (40%), Makurdi (9%) and Lafia (9%). The major finding is that the concentration of DC/WHs is in Abuja.

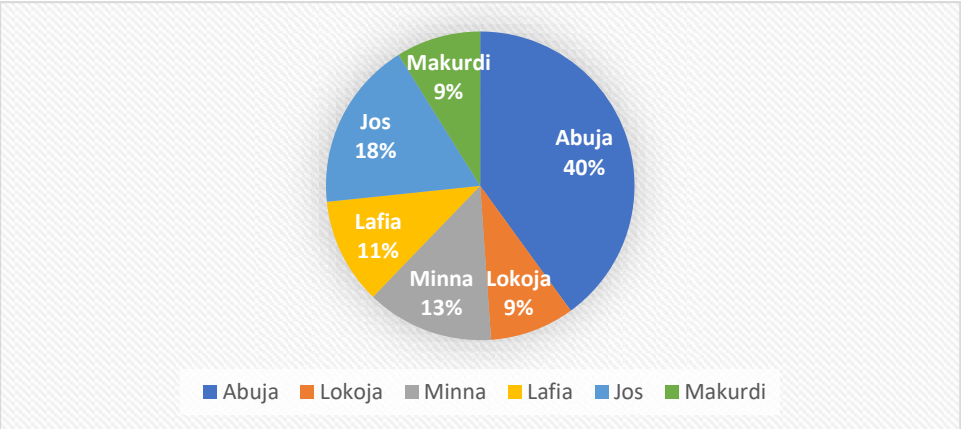

Figure 5.44: Location and Number of DC/WHs and Retailer Stores - MFC Site 6
Source: Researcher's Field Survey (2019)

5.2.6.4 Case Study 6: Method of Packaging of Materials Used by MFC Site 6

Figure 5.45 indicates that two methods, standard pallets and cartons, were used for the packaging of ceramic tiles. The process of packaging was the same as in Case Study 4. But, in this case, the pallets were of two different sizes due to the size of the ceramic tiles. A detailed analysis of the packaging of the products is presented in Table

5.8. However, it was observed that the pallets were used for storage only, not for transportation. This suggests under-utilisation of the pallets. There was no unit load to ease handling. This also led to multiple handling in the loading and offloading of material, in addition to being labour intensive and contributing to increasing of cost.

Table 5.8: MFC Site 6 Packaging Analysis of Product

S/N	Design type	Area per metre square	Pieces per carton	Weight per carton (kg)	Cartons per pallet
1	250x400mm screen digital	1.5	15	20.5	64
2	400x400mm	1.92	12	22.5	40
3	450 x450 mm Glossy black	1.42	7	28	48
4	300 x300mm	1.5	17	20.5	54
5	600 x 600mm Glossy	1.44	4	32	34
6	600 x 600 mm Black	1.44	4	32	34
7	600 x 600 mm Polish	1.44	4	32	34
8	600 x 600 mm Porcelain	1.44	4	32	34
9	600 x 600 mm Lion king	1.44	4	32	34

Source: Researcher's Field Survey (2019)

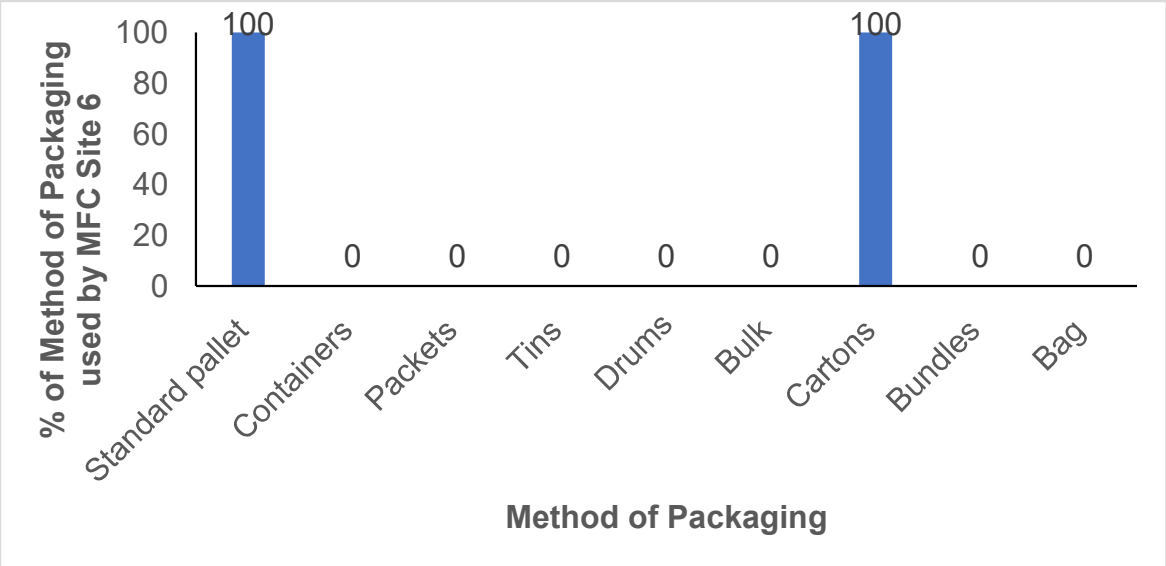

Figure 5.45: Standard Pallet and Carton Method of Packaging by MFC Site 6
Source: Researcher's Field Survey (2019)

5.2.6.5 Case Study 6: Method of Storage and Space Utilisation by MFC Site 6

Figure 5.46 indicates the method of storage/equipment. It shows that the pallet flow rack is the preferred method used by MFC Site 6. The process is as for Case Study 5.

It was noted that 75% of the floor area and 75% cube method space were utilised, while 75% of building space was utilised. This signifies that there is a balance between floor and cube method space utilisation, creating space on the floor area for movement of people and equipment.

Figure 5.46: Standard Pallet Floor Rack Storage Method used by MFC Site 6
Source: Researcher's Field Survey (2019)

5.2.6.6 Case Study 6: Vehicle Ownership by MFC Site 6

Figure 5.47 shows the type of ownership of vehicles used in delivering material to DC/WH and retailer stores. It was observed that 100% of the vehicles used were owned by third-party transport providers. The MFC Site 6 does not provide an in-house transport system. This signifies that MFC Site 6 does not provide Direct-end - user delivery. All customers take responsibility for transportation.

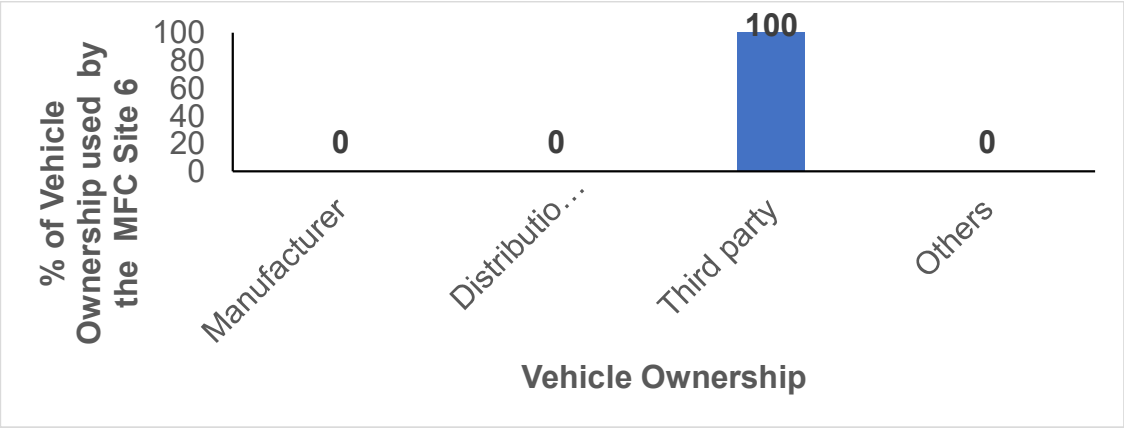

Figure 5.47: Vehicle Ownership for MFC Site 6
Source: Researcher's Field Survey (2019)

5.2.6.7 Case Study 6: Method of Loading Vehicles at MFC Site 6

The method of loading the vehicle is presented in Figure 5.48. This indicated two methods: manual loading and forklift trucks were used for moving ceramic tiles into vehicles for shipment. The detailed process of loading is the same as in Case Study 5.

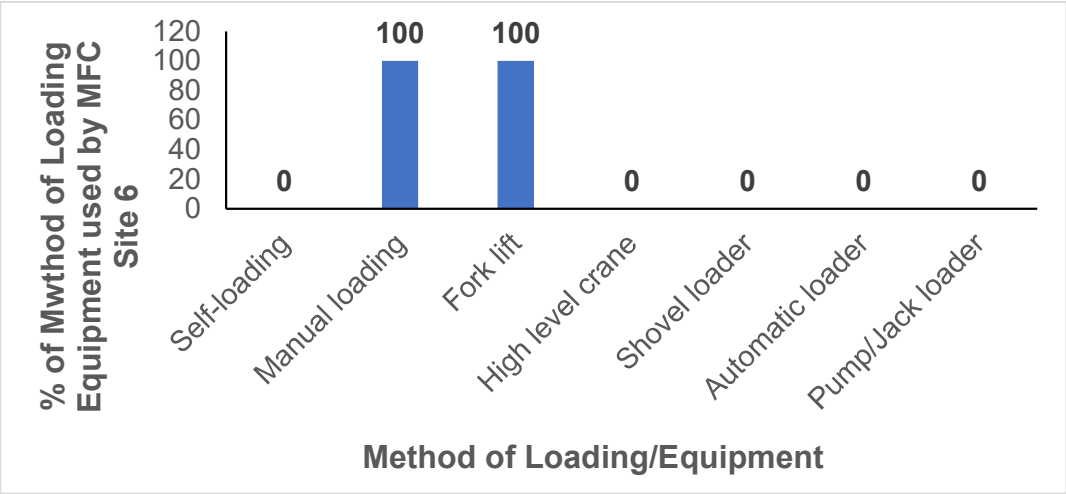

Figure 5.48: Methods Used in Loading Vehicles at MFC Site 6
Source: Researcher's Field Survey (2019)

5.2.6.8 Comments/summary analysis Case Study 6: MFC Site 6

The table 5.9 presents comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.9: Summary of Analysis of MFC Site 6

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	2no Channels Direct-to-end user Agent/marketer/distributor/wholesaler-retailer- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja one third of total nos and others fairly spread	Fair spread across state
3	Method of packaging	Packaging material- wooden pallet and carton	Efficient
		Packaging method – Semi-Automated (use fork lift truck and manual)	Efficient
4	Vehicle Ownership	Manufacturer in house -None	Inefficient
		Distributors/Retailers None	Inefficient
		Third Party (Outsourcing) –All used it	Inefficient
5	Method of Loading	Manufacturers warehouse- Semi-Automated loading (use fork lift truck and manual)	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites- Manual	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	Efficient
		DC/WH/Retailer stores and sites- Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Field Survey (2019)

5.2.7 Case Study 7: MFC Site 7

5.2.7.1 Case Study 7: MFC Site 7 - Overview

MFC Site 7 Plant, is a Nigerian construction company that owns and operates quarry plant used to extract high-quality crushed stones. The quarry site is providing for a variety of customers. The quarries have a capacity of over two million MTPA. The crushed stones produced by the company meet international standards, and the size of the crushed stones can be adjusted to customer needs.

5.2.7.2 Case Study 7: Logistics Channels Utilised by MFC Site 7

Figure 5.49 indicates two alternative logistics channels used by MFC Site 7 for the delivering of crushed stones to its customers. These channels were: Direct -end-user and Agent/ depositor-distributor/ wholesaler-retailer-end -user. In the case of Direct-end-user, the big construction company or individuals must register and deposit a minimum of 2.5 million Naira (R 84,000) for 1000 tonnes of crushed stones. Once the payment is confirmed by the Accounts Department, the Sales/marketing Department produced an invoice and Authority to Collect (ATC). Thereafter, the customer brings in trucks to load the material as the company does not provide transport.

The other logistics channel is coordinated by Agent/Depositors. The MFC Site 7 has eight (8) registered depositors who are members of the Nigeria Union of Mine Workers. They deposit a minimum of 2.5 million Naira (R 84,000) with the company for 1000 tonnes (minimum order quantity) of crushed stones. All the other customers procure material through the depositors. The depositors work as marketing agents for the company and are paid on a commission basis. The Direct-end-user channel has the potential to reduce lead time compared to the Depositor-distributor/wholesaler channel. The major finding was that two channels were used for the delivery of crushed stones by MFC Site 7.

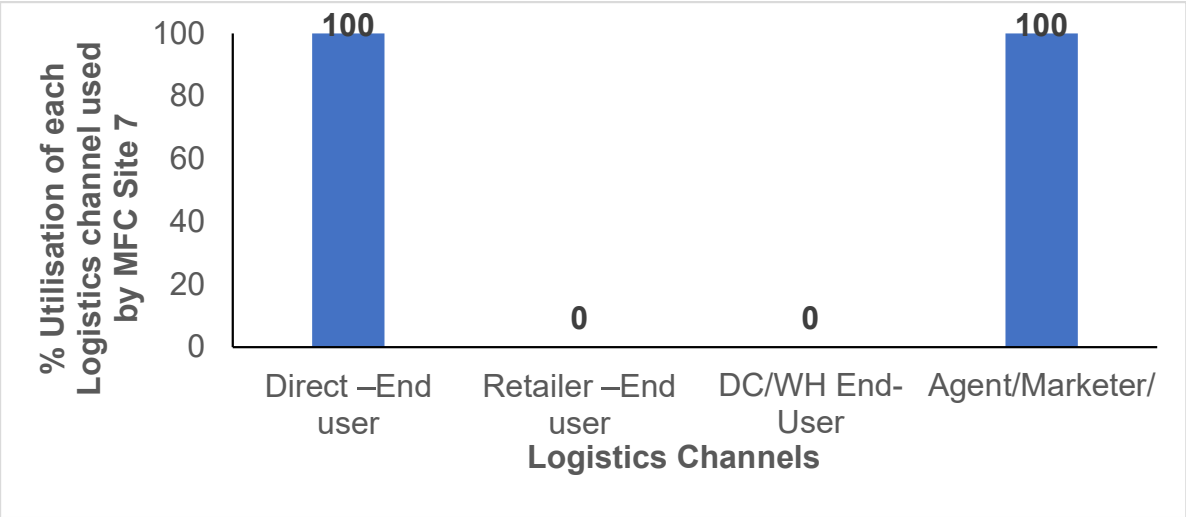

Figure 5.49: Logistics Channels Utilised by MFC Site 7
Source: Researcher's Field Survey (2019)

5.2.7.3 Case Study 7: Location and Number of BM/MS utilised by MFC Site 7

Figure 5.50 shows the locations and numbers of BM/MS utilised by MFC Site 7 to distribute crushed stones within the study area. It revealed the following: Abuja (75%), Minna (3%), Lafia (2%), Jos (2%) and Makurdi (2%). This indicates a concentration of depositors and BM/ MS in Abuja, where there was high volume of construction work.

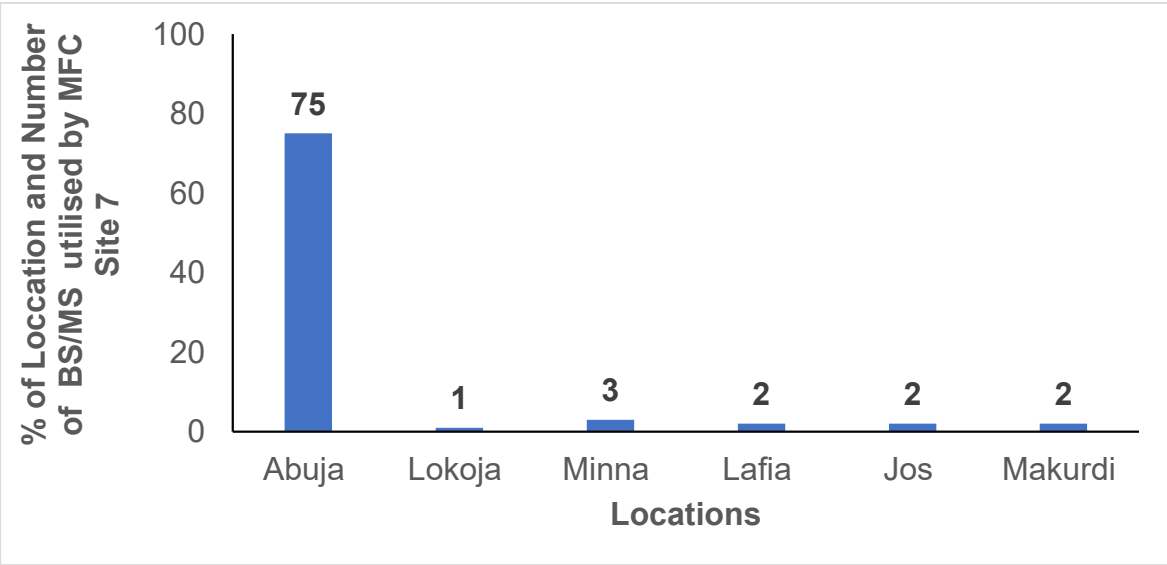

Figure 5.50: Location and Number of BM/MS for MFC Site 7
Source: Researcher's Field Survey (2019)

5.2.7.4 Case Study 7: Method of Packaging of Materials utilised by MFC Site 7

Figure 5.51 indicates that the method used in MFC Site 7 was bulk packaging, because this is unpacked material with low value to weight ratios. The crushed stones are homogeneous, loose material. It is classified as dry bulk material which can be easily transported using tippers and trailers.

Figure 5.51: Bulk Method of Packing Crushed stones in MFC Site 7
Source: Researcher's Field Survey (2019)

5.2.7.5 Case Study 7: Method of Storage and Space utilisation by MFC Site 7

Figure 5.52 indicates that the storage of materials was the floor block method in MFC Site 7. Normally, level and ramped ground was prepared before crushed stones were stock piled in bulk on it. Up to 75% of the floor and 50% of the cube method of space utilisation was observed. However, it must be noted that the crushed stones were stored in open spaces, not inside a building.

Figure 5.52: Floor Block Storage of Crushed stones in MFC Site 7
Source: Researcher's Field Survey (2019)

5.2.7.6 Case Study 7: Vehicle Ownership by MFC Site 7

Figure 5.53 indicates that in MFC Site 7, 100% of vehicles used for the delivery of crushed stones were third party logistics providers. The MFC Site 7 does not operate an in-house transport system, therefore all customers must make arrangement for

their deliveries. However, it was observed that MFC Site 7 agents and BM/MS prefer to outsource transport operations.

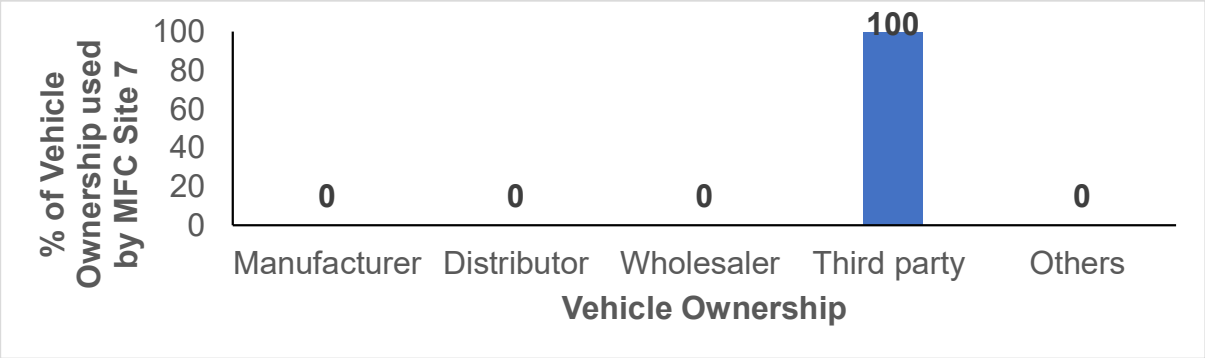

Figure 5.53: Vehicle Ownership for MFC Site 7
Source: Researcher's Field Survey (2019)

5.2.7.7 Case Study 7: Method of Loading Vehicles Used at MFC Site 7

Figure 5.55 presents the methods of loading crushed stones into vehicles for shipment. A shovel loader was used in loading the vehicles in MFC Site 7. This was a faster method to load material into a truck as there was no manual handling. Thus, the process was mechanically driven, increasing productivity and reducing loading time. In addition, Figure 5.54 Figure 5.55 and Figure 5.56 show a crushing machine, loading of crushed stones and a loaded vehicle on a weighing bridge.

Figure 5.54: Stone Crusher **Figure 5.55: Loading of Crushed Stones** **Figure 5.56: Loaded on Weighing Bridge**

Source: Researcher's Field Survey (2019)

5.2.7.8 Comments/summary analysis Case Study 7: MFC Site 7

The table 5.10 presents comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.10: Summary of Analysis of MFC Site 7

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	2no Channels Direct-to-end user Agent/marketer/distributor/wholesaler-retailer- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja - majority are located here	Not fair spread across state
3	Method of packaging	Packaging material- Loose /bulk	inefficient
		Packaging method – unpacked material	Efficient
4	Vehicle Ownership	Manufacturer in house -None	Inefficient
		Distributors/Retailers None	Inefficient
		Third Party (Outsourcing) –All used it	Inefficient
5	Method of Loading	Manufacturers warehouse- Semi-Automated loading (use shovel loader)	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites- Manual and tipping mechanically	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	Efficient
		DC/WH/Retailer stores and sites- Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Field Survey (2019)

5.2.8 Case Study 8: MFC Site 8

5.2.8.1 Case Study 8: MFC Site 8 - Overview

The MFC Site 8 is a quarry plant. The crushed stones sites have advanced technical equipment available to make very high-quality fine and coarse crushed stones. The company has the capability to blast for the required material and to sort the crushed stones within a few days, thus meeting customer needs. The quarry has a capacity of over 3.5 million MTPA. The crushed stones produced by MFC Site 8 meets global standards in quality and size.

5.2.8.2 Case Study 8: Logistics Channels Utilised by MFC Site 8

Figure 5.57 presents the logistics channels used for distributing crushed stones by MFC Site 8. Two channels: Direct-end-user and Agent/depositor-BM/MS-end- user were used. These two channel processes as in Case Study 7.

The MFC Site 8 has 75 registered depositors who are members of the Nigeria Union of Mine workers, and they have deposited a minimum of 2.5 million Naira (R 84,000) with the company for 1000 tonnes (minimum order quantity) of crushed stones. All other customers procure materials through the depositors. The processes are the same as in Case Study 7. The major finding was two multiple channels were used by MFC Site 8.

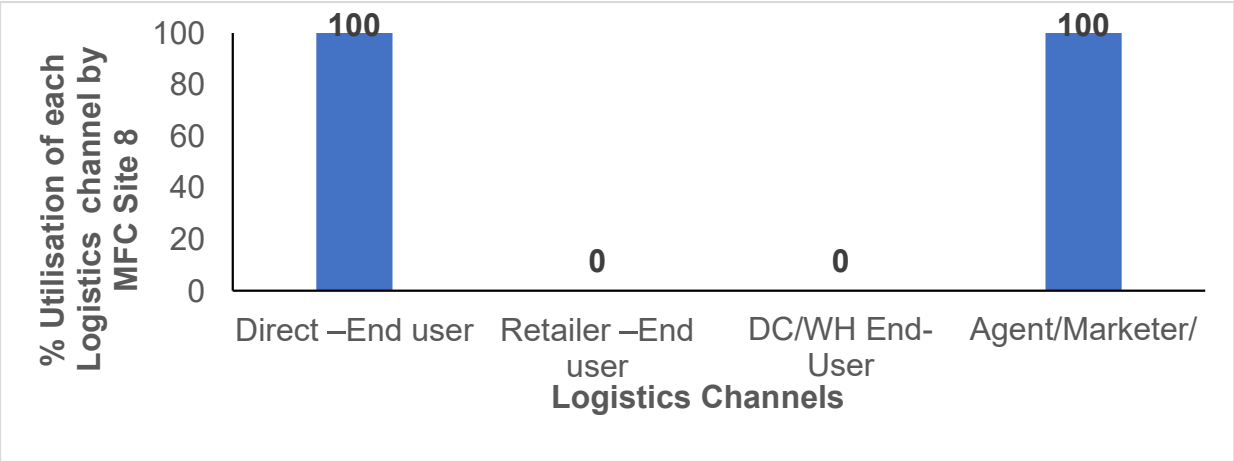

Figure 5.57: Logistics Channels utilised by MFC Site 8
Source: Researcher's Field Survey (2019)

5.2.8.3 Case Study 8 Location and Number of BS/MS Utilised by MFC Site 8

Figure 5.58 presents the location and number of agent/depositors and BM/MS within the study area. It established the following: Abuja (88%). Minna (3%), Lafia (2%), Jos (2%) and Makurdi (2%). This signifies that most of the agents/depositors and BM/MS were in Abuja, which suggests more demand in the area.

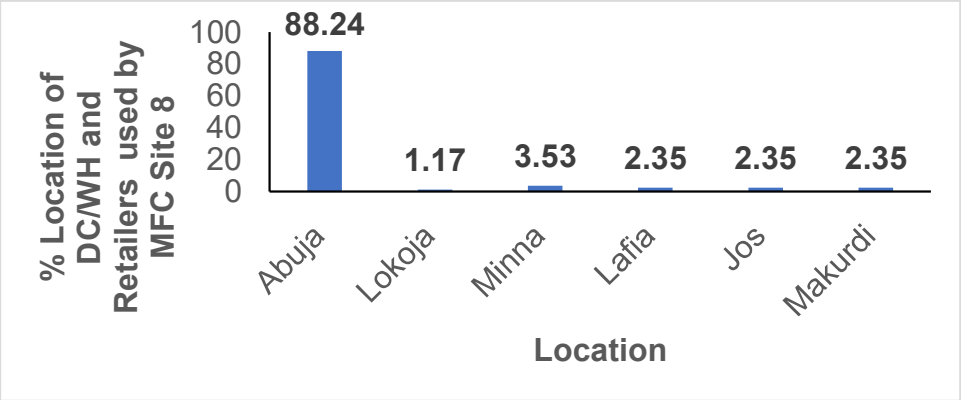

Figure 5.58: Location and Number of Depositors, BS/MS for MFC Site 8
Source: Researcher's Field Survey (2019)

5.2.8.4 Case Study 8: Method of Packaging of Material by MFC Site 8

The method of packaging crushed stones by MFC Site 8 was bulk (unpacked materials), which is the same process as in Case Study 7.

5.2.8.5 Case Study 8: Method of Storage and Space Utilisation by MFC Site 8

Figure 5.59 indicates the storage method used in MFC Site 8, which was floor block storage. The process is the same as for Case Study 7.

Figure 5.59: Floor Block Storage of Crushed stones in MFC Site 8
Source: Researcher's Field Survey (2019)

5.2.8.6 Case Study 8: Vehicle Ownership by MFC Site 8

Figure 5.60 indicates vehicle ownership types; showing that 100% of the vehicles used for delivery of material are owned by third-party transport providers. This has been explained in Case Study 7. The MFC Site 8 does not operate an in-house transport system.

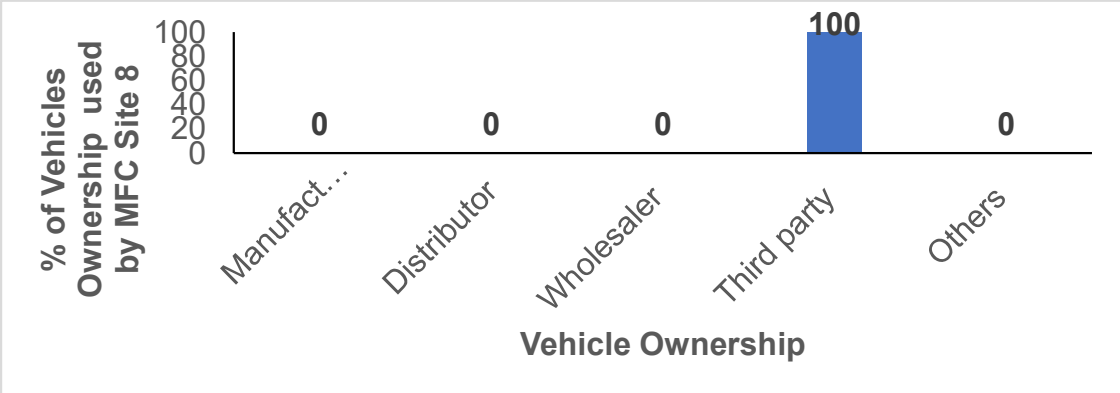

Figure 5.60: Vehicle Ownership Types used for Delivery from MFC Site 8
Source: Researcher's Field Survey (2019)

5.2.8.7 Case Study 8: Method of Loading Vehicles utilised at MFC Site 8

Figure 5.61 shows the method of loading in MFC Site 8, namely a shovel loader. The process of using the shovel loader has been explained in Case Study 7. In addition, Figure 5.62 shows the weighing of vehicles before and after loading to determine the actual tonnage being shipped.

Figure 5.61: Shovel loader and Method of Loading Crushed stones in MFC Site 8

Figure 5.62: Vehicles on Weighing Bridge

Source: Researcher's Field Survey (2019)

5.2.8.8 Comments/summary analysis Case Study 8: MFC Site 8

The table 5.11 presents comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.11: Summary of Analysis of MFC Site 8

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	2no Channels Direct-to-end user Agent/marketer/distributor/wholesaler-retailer- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja - majority are located here	Not fair spread across state
3	Method of packaging	Packaging material- Loose /bulk	inefficient
		Packaging method – unpacked material	Efficient
4	Vehicle Ownership	Manufacturer in house -None	Inefficient
		Distributors/Retailers None	Inefficient
		Third Party (Outsourcing) –All used it	Inefficient
5	Method of Loading	Manufacturers warehouse- use shovel loader	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites- Manual and tipping mechanically	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	Inefficient
		DC/WH/Retailer stores and sites- Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Field Survey (2019)

5.2.9 Case Study 9: MFC Site 9

5.2.9.1 Case Study 9: MFC Site 9 - Overview

In Nigeria, it is hard to identify precise locations of either private or commercial block manufacturers. Several of these locations are scattered throughout the nation. Owing to the profitable nature of block production, almost every Local Government Area (LGA) has one or more small or large-scale block production factories to meet the demand of construction and infrastructural development (Oyekan and Kamiyo, 2008:735; Abdullah, Bilau, Enegbuma, Ajagbe, Ali, and Bustani, 2012:35). Human resources in both skilled and unskilled labour are required to ease the moulding and curing processes for the manual and machine moulding types. There are essentially three kinds of machines used in block moulding in Nigeria: Egg laying machines, Electric vibrating machines and Manual hand press machines. Some of these, in addition to compaction, also vibrate the blocks.

Sandcrete blocks are classified as solid or hollow blocks. Hollow blocks have cavities in them, while the solid ones have no cavities. The length, width and height of the major sizes of sandcrete blocks produced in Nigeria are as follows:

- 450 x 225x 225mm (hollow)
- 450 x 150 x 225mm (hollow)
- 450 x 150 x 225mm (solid)
- 450 x 125 x 225mm (solid).

5.2.9.2 Case Study 9: Logistics Channels Utilised by MFC Site 9

Figure 5.63 presents the alternative logistics channels utilised by MFC Site 9. It reveals two channels: Direct-end- user and BM/MS–end-user. The Direct–end -user process involves a customer placing an order directly to the block manufacturer, who processes and delivers the material to the end-user (the construction site). The Direct-end-user sale strategy leads to reduction in lead time, but sometimes the deliveries were Less than Truck Load (LTL). On the other hand, BM/MS-end- users obtain a procurement sub-contract from the main contractor/client, then place orders with the block manufacturers. There may be consolidation in transportation sometimes due to the large quantities ordered.

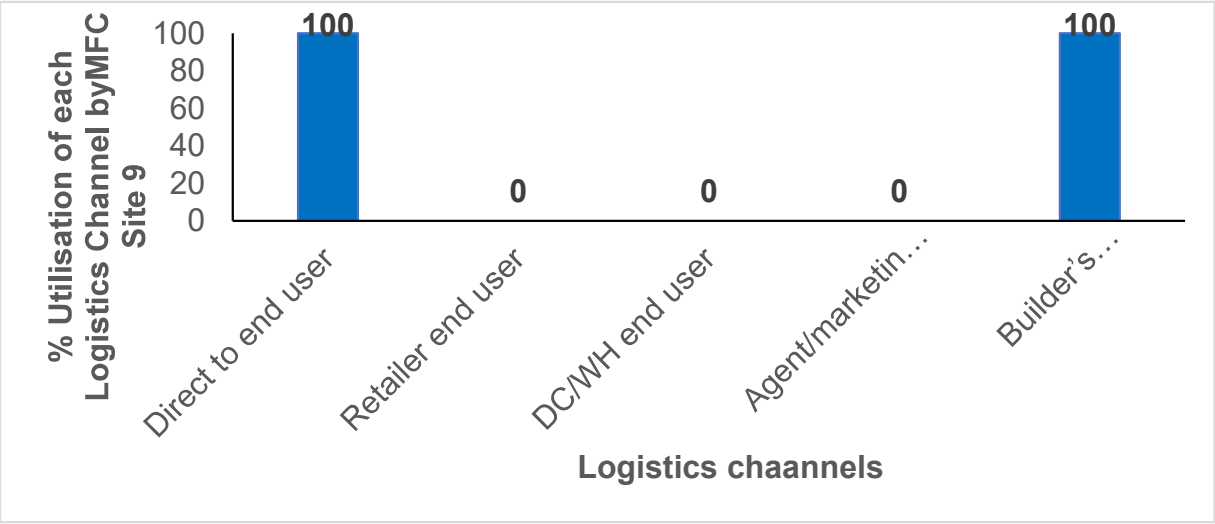

Figure 5.63: Logistics Channels utilised by MFC Site 9
Source: Researcher's Field Survey (2019)

5.2.9.3 Case Study 9: Location and Number of MFC Site 9

Data here were obtained from the Block Manufacturers Association of Nigeria. There is a total of 440 manufacturers within the study area. The result of the analysis is shown in Figure 5.64. It reveals that manufacturer are located as follows Abuja (41%),19% Jos (19%) and Makurdi (8%). This suggests a concentration of block manufacturers in Abuja, due clearly to the high volume of construction work there.

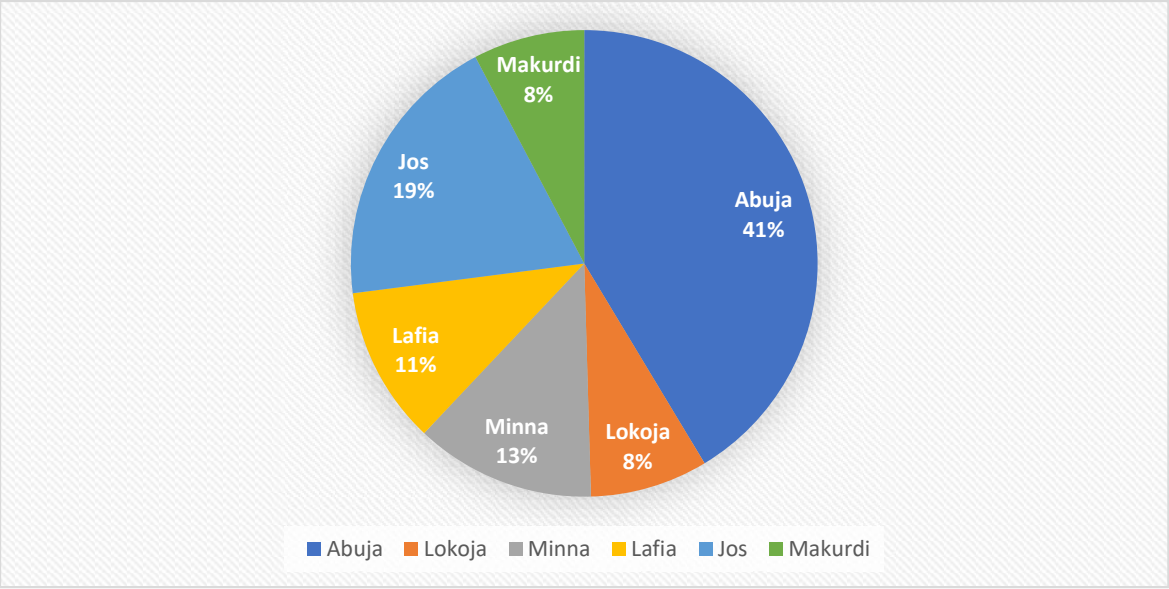

Figure 5.64: Location and Number of MFC Sites 9
Source: Researcher's Field Survey (2019)

5.2.9.4 Case Study 9: Method of Packaging utilised by MFC Site 9

Figure 5.65 indicates that there was no block packaging. The process observed involved the cured block being removed from the pallet. They are then stored in an open space. Cured blocks are removed to storage areas to provide more space for new blocks. The blocks require adequate care at this stage. It was observed that there was no use of standard pallets to form unit loads for ease of handling and transportation. Many blocks can get damaged at this stage due to poor handling. Therefore, the process suggests multiple handling of material in the block factories, which can lead to high labour and low productivity. Lack of use of standard pallets leads to multiple handing, reduction in safety and security in transport.

Figure 5.65: Wooden Pallets for Moulding Blocks and Curing/Stacking at a Typical Block Factory

Source: Researcher's Field Survey (2019)

5.2.9.5 Case Study 9: Method of Storage and Space utilisation by MFC Site 9

Figure 5.66 indicates that the floor/block storage method was adopted by MFC Site 9 The process involves stacking the blocks on a level and rammed ground surface in open spaces rather than a warehouse. Nigerian Industrial Standard (NIS) 87, (2001:34) requires that the blocks be stacked up to not more than 5 courses high. However, it was observed that no pallet was used for storage to provide for unit load handling. This led to multiple handling of blocks during loading and offloading as each block is taken separately.

The analysis of space utilisation established an average of 50% floor space and 25% of cube method space utilisation in the companies that make up the MFC Site 9.

Figure 5.66: Floor Block Storage Method in a Typical Block Factory
Source: Researcher's Field Survey (2019)

5.2.9.6 Case Study 9: Vehicle Ownership by MFC Site 9

Figure 5.67 presents the type of vehicle ownership used for the delivery of blocks 83% of the factories owned and operated their own transport system. 17% used the third-party transport providers. This suggests that most of the block factories use their own vehicles for delivery. In Nigeria, blocks are mostly transported to project sites on small and big trucks that carry between 50 and 1000 blocks at a time to avoid breakage. It was observed that all the vehicles used do not have loading or offloading devices such as cranes. This contradicts the assumption that the block manufacturers use trucks that have loading and offloading equipment.

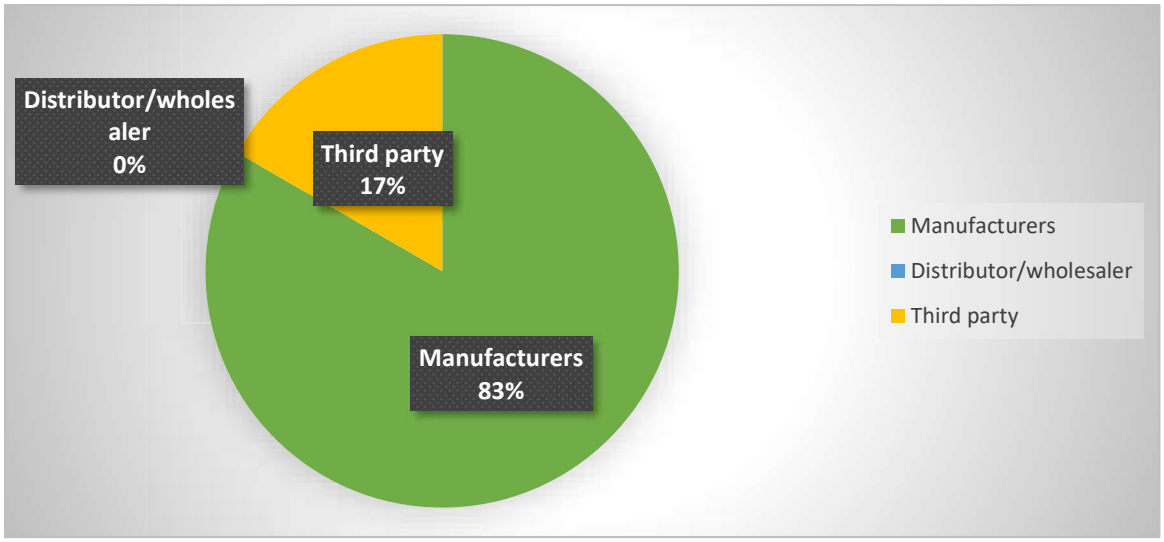

Figure 5.67: Vehicle Ownership Types Used for Delivery from MFC Site 9
Source: Researcher's Field Survey (2019)

5.2.9.7 Case Study 9: Method of Loading Vehicles at MFC Site 9

Figure 5.68 shows the manual loading method used for loading blocks into a truck. The process is manually done, labour intensive and increases loading time. The blocks are loaded and offloaded manually. There is multiple handling of blocks due to not using standard pallets for packaging.

It is a usual practice for block firms to transport the blocks to project sites for the buyers. The cost of such transportation is added to the cost of the blocks. Small firms that cannot afford to own a truck for transportation usually rent one when needed.

Figure 5.68: Manual Loading of Blocks in a Typical Block Factory
Source: Researcher's Field Survey (2019)

5.2.9.8 Comments/summary analysis Case Study 9: MFC Site 9

The table 5.12 present comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.12: Summary of Analysis of MFC Site 9

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	2no Channels Direct-to-end user Builders merchant- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja - majority are located here	Not fair spread across state
3	Method of packaging	Packaging material- pallet &Loose /bulk	inefficient
		Packaging method – unpacked material	Efficient
4	Vehicle Ownership	Manufacturer in house -Mostly use inhouse vehicles	Inefficient
		Distributors/Retailers None	Inefficient
		Third Party (Outsourcing) –less used	Inefficient
5	Method of Loading	Manufacturers warehouse- Manual	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites- Manual	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	inefficient
		DC/WH/Retailer stores and sites- Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Field Survey (2019)

5.2.10 Case Study 10: MFC Site 10

5.2.10.1 Case Study 10: MFC Site 10 - Overview

Sand is one of the most prevalent natural resources on earth. There are coarse and fine aggregate sources located in almost every region of the country. In North-Central Nigeria, sand is sourced from riverine areas. It is difficult to pinpoint exact areas as many of these locations are scattered throughout each state and the Federal capital territory, Abuja.

The Union of Tipper and Quarry Employers of Nigeria has representation across the country in State and Local Government. They are responsible for the supply of sand. Local government officials oversee mining sites, and miners of crushed stones and sand. Government officials (the Revenue Clerks from the Accounts Department of each Local Government Council) are responsible for collection of revenue. The amount of money charged for each tipper by the local government per trip ranges between N500- N1500, depending on the truck size and type of sand.

5.2.10.2 Case Study 10: Logistics Channels Utilised by MFC Site 10

Figure 5.69 presents graphically the alternative logistics channels for sand delivery. It reveals two channels: Direct-end-user and BM/MS-end-users were used for the delivery of sand to customers (construction sites). The Direct-end user process involves a customer placing an order directly through the Union of Tipper and Quarry Employers of Nigeria. Once the order is processed, the delivery is made to the customer. In the case of BS/MS, they obtain subcontracts from the main contractors/clients, then place the order through any member of the Union of Tipper and Quarry Employers of Nigeria. Thereafter, deliveries are made to customers or construction sites.

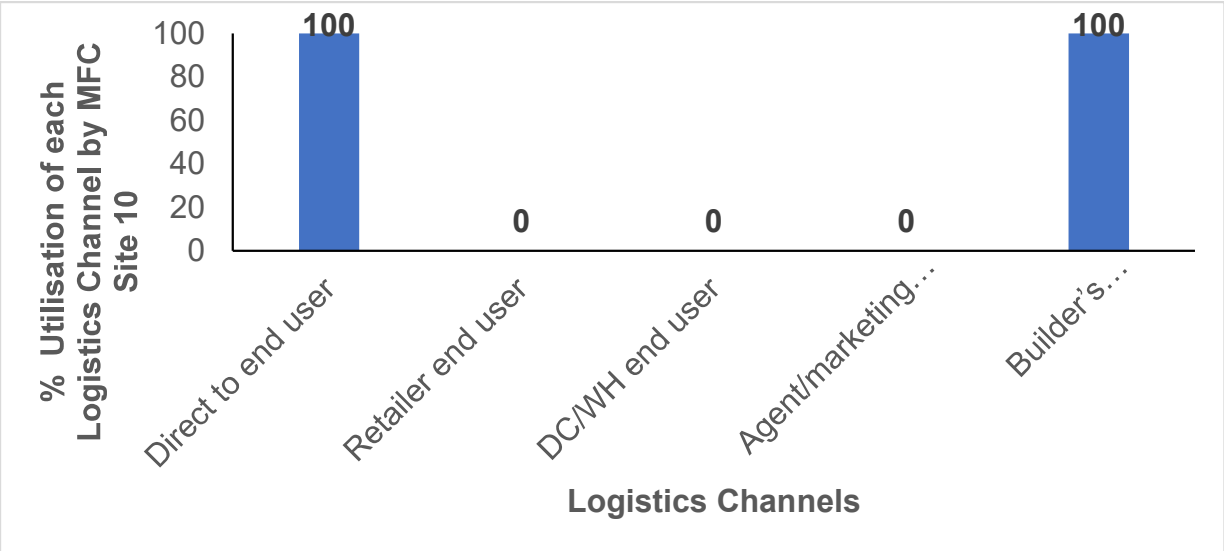

Figure 5.69: Logistics Channels Utilised by MFC Site 10
Source: Researcher's Field Survey (2019)

5.2.10.3 Case Study 10: Location and Number of MFC Site 10

Data obtained on the registered number of members and locations of the Union of Tipper and Quarry Employers of Nigeria is presented in Figure 5.70. It reveals the following distributions: Abuja (53%), Jos (17%) and Lokoja (5%). This shows that half of the operators of sand delivery were in Abuja, which suggests a high volume of construction work in the area.

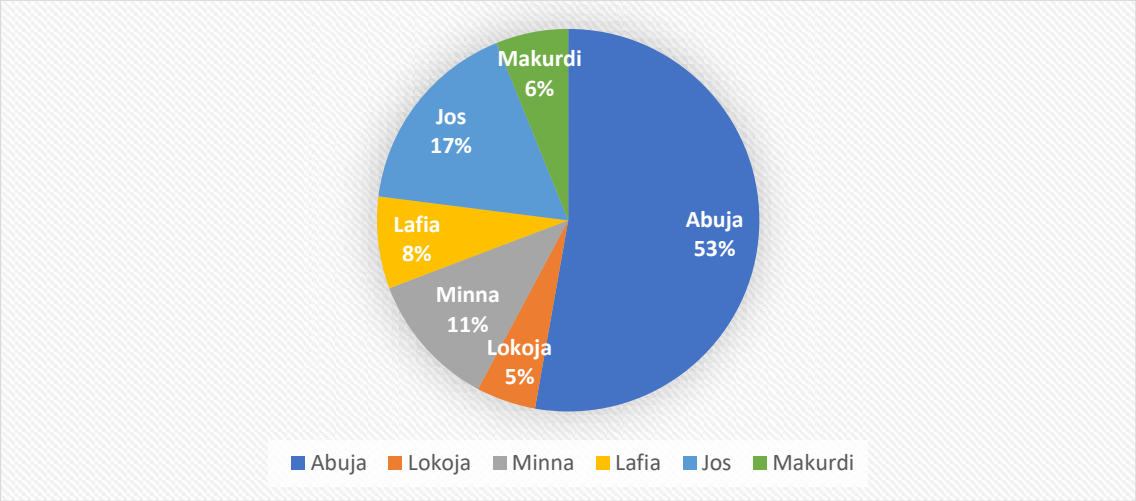

Figure 5.70: Location and Number of Tipper and Truck Employers of Nigeria
Source: Researcher's Field Survey (2019)

5.2.10.4 Case Study 10: Method of Packaging Utilised by MFC Site 10

Figure 5.71 indicates methods of packaging of the materials. It shows sand in its bulk form. It is worth noting that sand is sourced in a homogenous loose form. The material

is transported in dry-bulk form and requires no packaging. No packaging or unpacking of material is required.

Figure 5.71: Sand in loose form (Bulk) and Dredging of Sand from a River
Source: Researcher's Field Survey (2019)

5.2.10.5 Case Study 10: Method of Storage and Space Utilisation by MFC Site 10

The analysis of storage of sand revealed that 17% of companies used floor block storage. This is achieved by dredging and stockpiling the sand. Also, 83% of the companies sourced the sand in its natural state, as shown in Figure 5.72. Sand is either found by the side of the river, on land or on the river bed. Therefore, the floor, cube-method and building space utilisation was not assessed in most towns, except for Lokoja. The cube–method space utilisation at Lokoja was 50%, because of dredging of the sand. The implication of this finding is that it would be difficult to access the river and sourcing of sand during the peak of the rainy seasons.

Figure 5.72: Sand Stored in Natural Form and Stockpile after Dredging
Source: Researcher's Field Survey (2019)

5.2.10.6 Case Study 10: Vehicle Ownership by MFC Site 10

The type of vehicle ownership data was analysed and presented in Figure 5.73. It shows 100% of vehicles used were owned by third party transport operators. This

established that all the vehicles used for the delivery of sand were owned by the third-party transport providers, which indicates their capability and competence in service delivery.

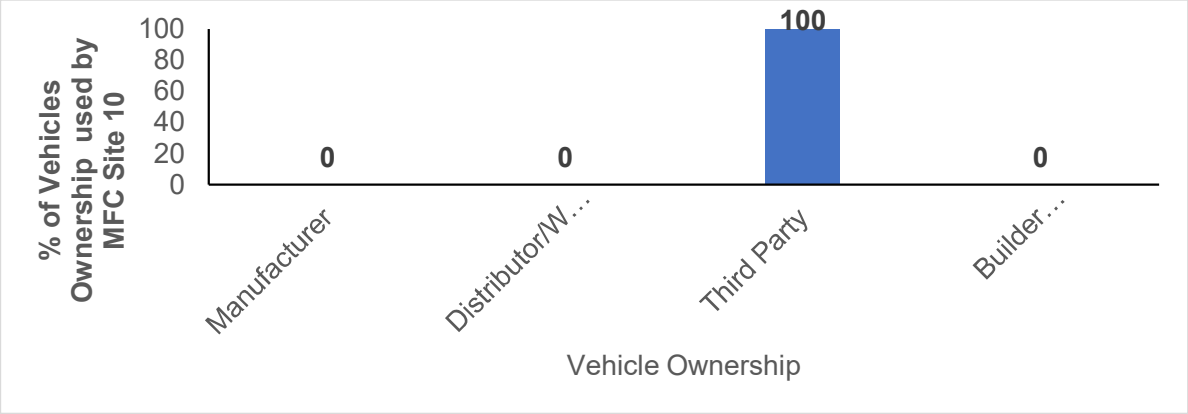

Figure 5.73: Vehicle Ownership Types Used for Sand Delivery MFC Site 10
Source: Researcher's Field Survey (2019)

5.2.10.7 Case Study 10: Method of Loading Vehicles Used at MFC Site 10

Figure 5.74 shows the method of loading sand into trucks. Up to 83% of companies used manual loading, while 17% used a shovel loader. Before these aggregates get incorporated into the structures, they undergo a series of processes which entail multiple handling, involving various types and grades of labour and machines.

The bulk materials can be loaded by using a shovel loader or manually (hand loading) and offloaded by self-tipping. When the process is manually done, it is usually labour intensive and increases loading time and cost. The findings indicate that most companies used the manual loading method for loading sand into a truck.

Figure 5.74: Shovel loader and Manual Methods of Loading Sand into Trucks for Delivery
Source: Researcher's Field Survey (2019)

5.2.10.8 Comments/summary analysis Case Study 10: MFC Site10

The table 5.13 present comments/summary analysis on each factor in terms of efficiency. The table highlights strong and weak areas of each site/project at a glance.

Table 5.13: Summary of Analysis of MFC Site 10

S/No	Factors	Comments/Summary of analysis	Remarks in terms of Efficiency
1	Logistics channels used	2no Channels Direct-to-end user Builders merchant- End user	Weak
2	Location and No of DC/WH/Retailer	Abuja - majority are located here	Not fair spread across state
3	Method of packaging	Packaging material- pallet &Loose /bulk	inefficient
		Packaging method – unpacked material	Efficient
4	Vehicle Ownership	Manufacturer in house -Mostly use inhouse vehicles	Inefficient
		Distributors/Retailers None	Inefficient
		Third Party (Outsourcing) – Mostly use	Inefficient
5	Method of Loading	Manufacturers warehouse- Manual	Efficient
6	Method of Offloading	DC/WH/Retailer stores and sites- Manual	Inefficient
7	Storage space utilisation	Manufacturers warehouse- Floor, cubic and Pallet utilisation	inefficient
		DC/WH/Retailer stores and sites- Floor, cubic and Pallet utilisation	Inefficient

Source: Researcher's Field Survey (2019)

5.3 The Combined Research Results for Manufacturing Companies (MFC Sites 1-10)

The relevant data for individual case studies has been presented in Section 5.2, with descriptive analysis that highlighted the results from across the case studies. This next section presents the combined research results for manufacturing companies 1-10 (MFC Sites 1-10). It progresses thematically as follows:

- an analysis of logistics channels;
- analysis of Logistics Systems - Collaboration and Integration;
- efficiency in warehousing and transportation sub-systems;
- technology application and effectiveness of customer satisfaction; and,
- a framework for improving the efficiency and effectiveness of Management-CMLS.

5.3.1 Analysis of Logistics Channels

Logistics channels are important for efficient Management-CMLS, as well as for customer satisfaction. This forms an important aspect of this research study, as it identifies the current logistics channels of construction material used by manufacturers in Nigeria.

5.3.1.1 Logistics Channels Utilised by MFC Sites 1-10

Figure 5.75 presents the results of the analysis of companies using each of the five identified logistics channels in the delivery of materials. It was established that 100% of companies used the Direct-end -user channel, which bypassed all other intermediaries in the supply chain. It was also established that 60% of the companies used the Agent/Marketer-distributors/wholesalers-retailer-end-user channel. Furthermore, 40% of the companies used BM/MS-end- user channels, and 30% used DC/WHS- retailer- end-user channels.

In summary, it revealed that 70% of companies used two channels, while the remaining 30% used three channels in the delivery of their products to customers. The significant findings were that all the companies used the Direct-end -user channels, while the majority used Agent/marketer-distributor/wholesaler and retailer-end-user channels for delivery.

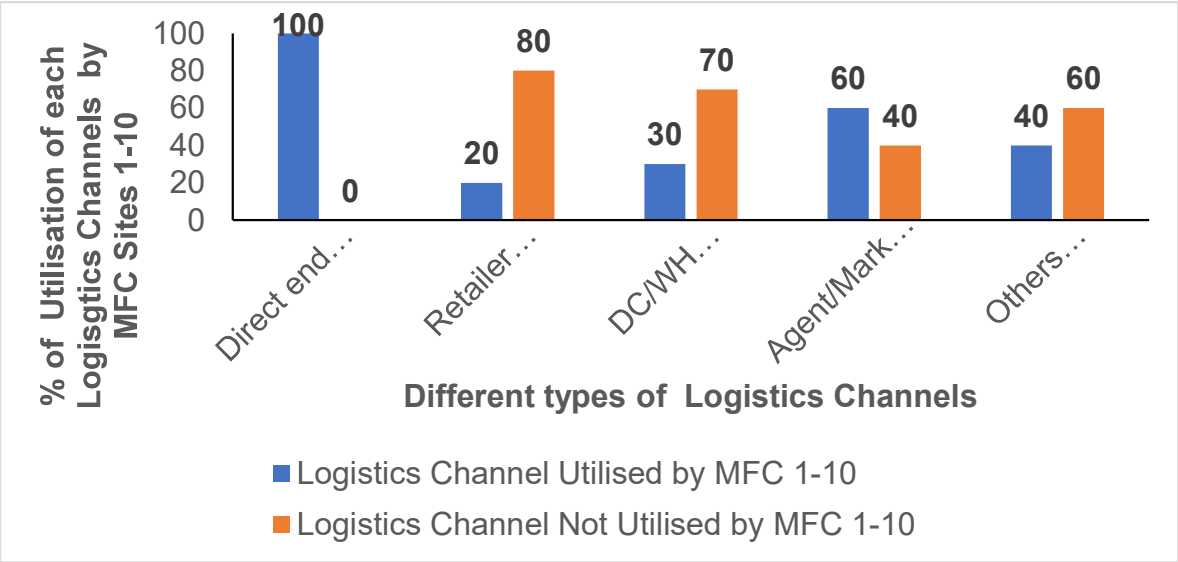

Figure 5.75: Logistics Channels Utilised by MFC Sites 1-10
Source: Researcher's Field Survey (2019)

5.3.1.2 Location and Number of DC/WHs and Retailer Stores used by MFC Sites 1-10

The chart in Figure 5.76 presents the number of DC/WHs and retailer stores that are in the various state capitals. The findings show that 49% of all DC/WH and, retailer stores are in Abuja. It was also established that Minna had 12%, and Jos had 16%. This confirms that almost half of the DC/WHs and retailer stores are concentrated in Abuja. Locating a DC/WH strategically and in most cost-effective geographic location is one of most important decisions that a company must make. The fact that a great deal of difference exists between the geographical market and other factors, such as travel minimisation and total cost, play a key role in determining location and number of DC/WHs to be established.

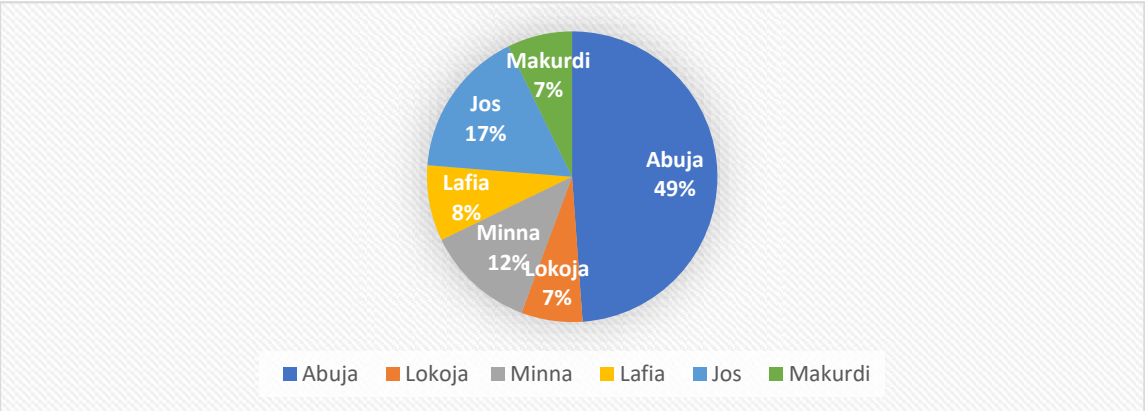

Figure 5.76: Location and Number of DC/WHs and Retailer Stores
Source: Researcher's Field Survey (2019)

5.3.1.3 Network Structures Used in DC/WHs and Retailer Stores for MFC Site 1-10

The type of network structures used in the DC/WHs and Retailer stores were analysed. The findings revealed that 93% of DC/WHs and Retailer stores were mixed warehouse structures, while 7% were consolidated warehouses as presented in Figure 5.77.

In a mixed warehouse, deliveries from several manufacturing plants arrive as Full Truck Load (FTL) consignments to the DC/WH and Retailer stores. The deliveries are broken up and then consolidated once more to create several multi-product FTL shipments. Each of these multi-product FTL shipments goes as a direct delivery to one of the several retailers/customers. Smaller lots are sent as Less than Truck Load (LTL) shipments to smaller retail outlets or to customers located nearby. Therefore, a mixed warehouse combines network structures of both consolidation and break-bulk warehouses, as shown in Figure 5.78.

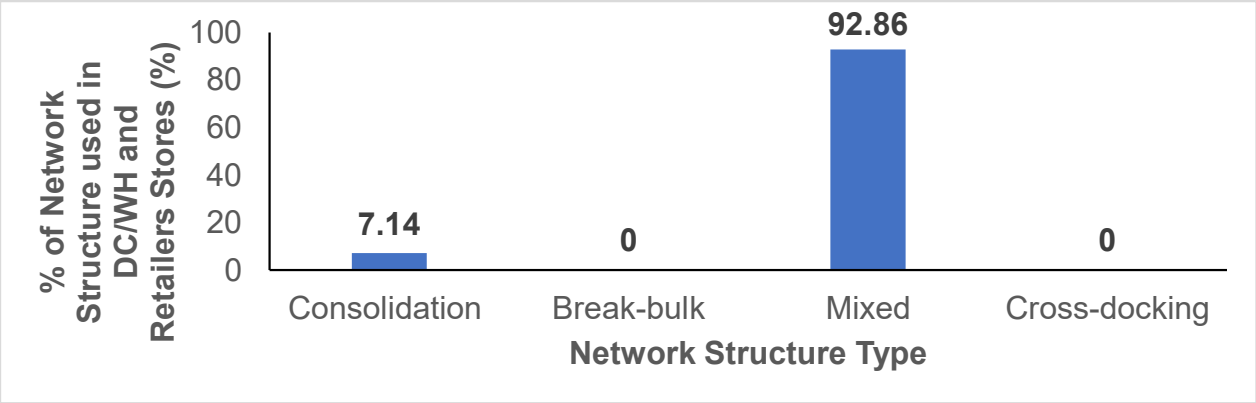

Figure 5.77: Network Structures Used in DC/WHs and Retailer Stores
Source: Researcher's Field Survey (2019)

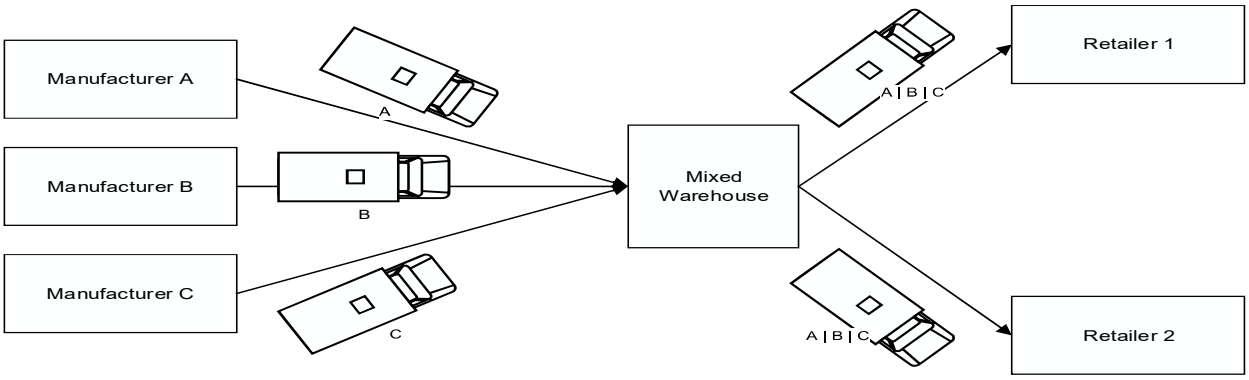

Figure 5.78: Network Structure for Mixed Warehouses
Source: Modified from Ballou (1999)

5.3.1.4 Floor Size of DC/WHs and Retailer Stores Used by MFC Sites 1-10

The result of the analysis of floor sizes of the DC/WHs and Retailer stores is presented in Figure 5.79. It shows that 80% of the DC/WHs and Retailer stores sizes were less than 500 m² and 17% were between 5001-3000 m². The significance of the finding is that the majority of the DC/WH were small sizes (less than 500 m²), and therefore have limited capacity for large stockholding. Most of the buildings were just 3.0m high, limiting their capacity for cube method storage, which is more cost effective. The implication is that an arrangement must be made for frequent delivery to satisfy demand. However, a significant finding was that crushed stones was being stored in an open space in three towns, Minna, Lafia and Makurdi.

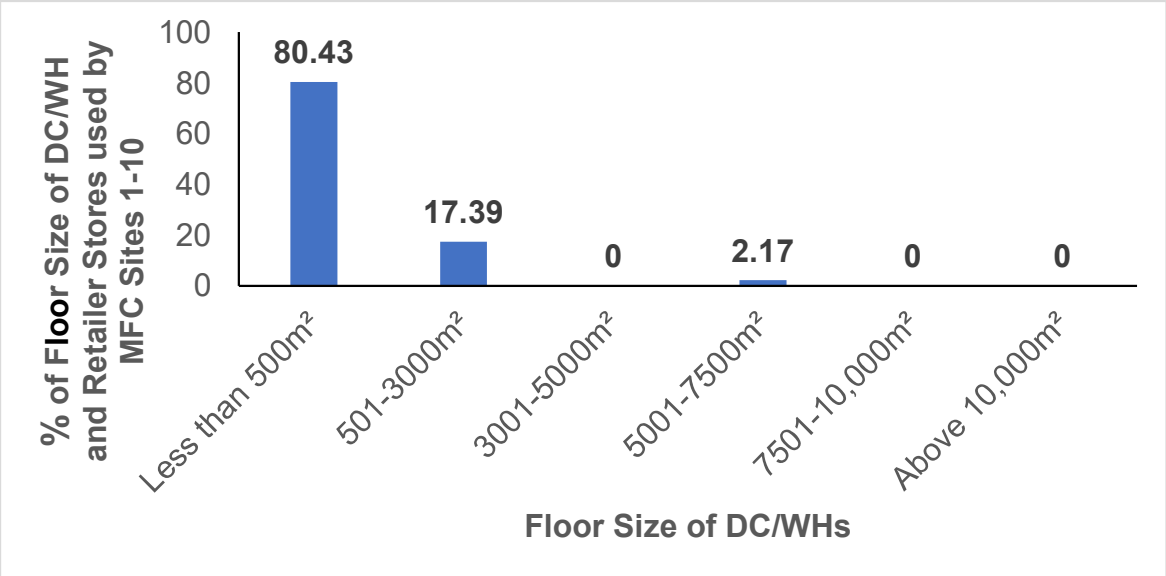

Figure 5.79: Floor Size of DC/WHs and Retailer Stores
Source: Researcher's Field Survey (2019)

5.3.1.5 Distance and Cost of Material Delivery utilised by MFC Sites 1-10

Cutting down of transport related costs can be achieved by the optimal location of the DC/WH. Based on the need to determine the transport related costs for this study, information was captured in such a way that it accommodated correlations between distance travelled, material quantities delivered and transportation costs. The four points identified for discussion follow:

- **Distance Between Individual Manufacturer Plants and DC/WH, Retailer Stores and Sites**

Figure 5.80 presents an analysis of distance between individual manufacturer plants to the DC/WHs, Retailer Stores and construction sites. It shows that manufacturer plant distances are between 151 and 350km to DC/WHs, Retailer stores. Sites were as follows for each material: cement (25%), reinforcement bars (42%), ceramic tiles (50%) and crushed stones (83%). In addition, 50% of cement manufacturing plant distances to DC/WHs and Retailer Stores were between 351-500km; while block (100%) and sand (92%) plant distances to construction sites were between 0-50km.

The major findings were that the majority of DC/WHs and Retailer Stores for ceramic tiles and granite were between 151-350km away from the manufacturer plants, while half of cement DC/WHs and Retailer Stores were between 351-500km away from cement plants. Most block manufacturers and sand quarries distances to construction sites were between 0-50km. This suggests that economies of transportation can be achieved for materials if distances were between 0-350km from the manufacturer plants to DC/WHs, Retailer Stores and Sites.

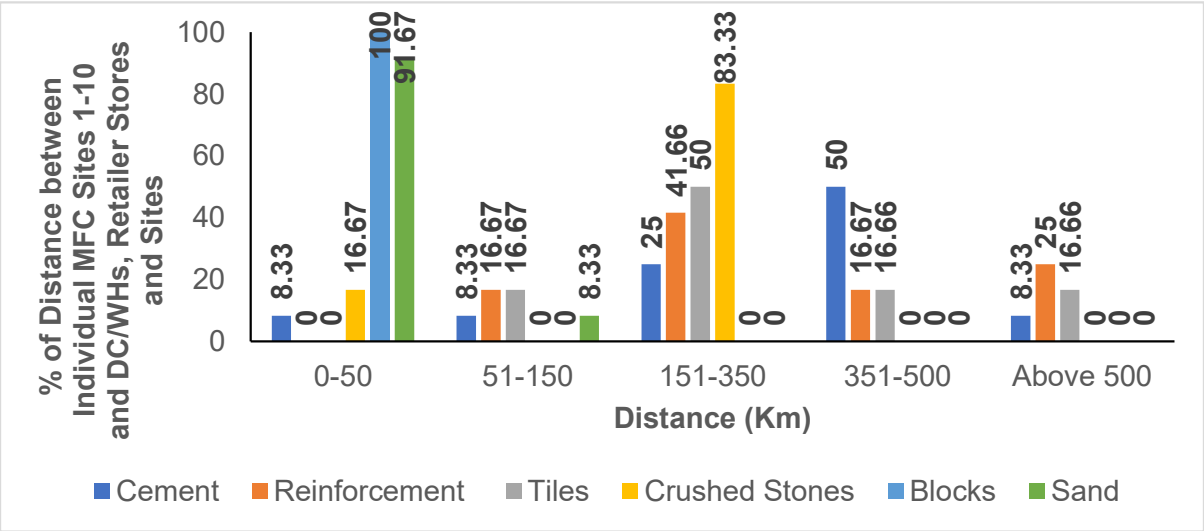

Figure 5.80: Distance Between Individual Manufacturer Plants and DC/WHs, Retailer Stores and Sites

Source: Researcher's Field Survey (2019)

- **Summary of Distances between Manufacturer Plants and DC/WHs, Retailer Stores and Sites**

Figure 5.81 indicates the summary of distances between manufacturer plants and DC/WHs, Retailer Stores and Construction Sites. Some 36% of DC/WHs were between 0-50 kilometres away from the manufacturer plants. Also, 35% of DC/WHs were located between 151–350 kilometres away from the manufacturer plants. The summation of findings for distances between 0-350 kilometre is 79%. This indicates that the majority of the DC/WHs and Retailers are located between 0 – 350 kilometres of the manufacturer plants. This is new in the Nigerian research profile.

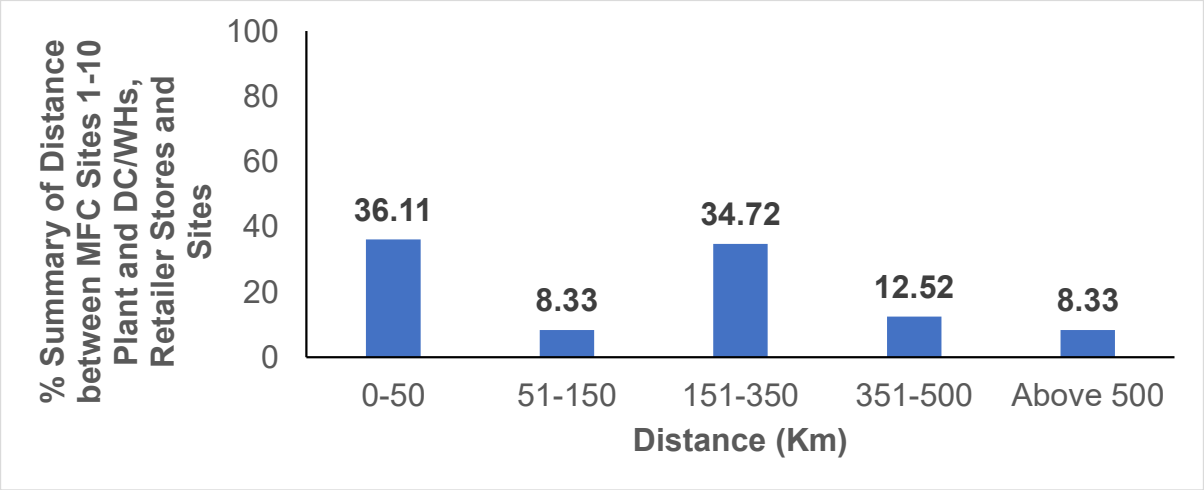

Figure 5.81: Summary of Distance Between Manufacturer Plants and DCS/WHs, Retailer Stores and Sites

Source: Researcher's Field Survey (2019)

- **Transportation Costs per Distance Travelled for Individual Materials**

Figure 5.82 presents the analysis of average transportation costs of individual material per average distance travelled and average transportation cost per average tonnes of material shipment. It established the average transportation cost per average distance for sand (₦776.89/km), granite (₦701.86/km) and reinforcement bars (₦572.10/km) as the three highest. Blocks have ₦128.71/km as the least average transportation cost per average distance of shipment.

In addition, the findings revealed that the average transportation cost per average tonnes of shipments for reinforcement (₦5,466.51/ton), tiles (₦5,167.60/ton) and cement (₦3,638.55/ton). The major findings were that the highest cost of material transport per distance was ₦776.89/km, and the least ₦128.71/km. The highest average transportation cost per average tons was ₦5,466.51, and the least was ₦1,037.23. These findings on average transport cost per average distance and average transport cost per average ton of shipment are significant findings which were not researched before.

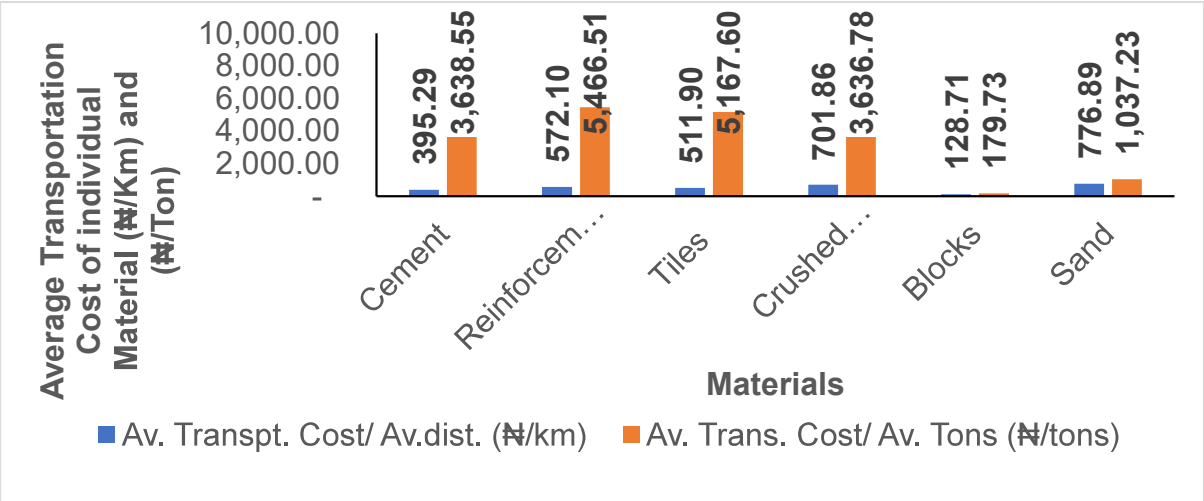

Figure 5.82: Transport Cost Per Distance Travelled and Transport Cost Per Tons Delivered
Source: Researcher's Field Survey (2019)

- **Summary of Average Transportation Cost of Material Per Average Distance Travelled**

The summary of correlation between average transportation cost per average distance for delivery of material is shown in Figure 5.83. The highest average transportation cost per average distance of ₦996.95/km was recorded between 51-150km. The trend that was noted was that the average transportation cost per average distance decreased as the distance increased in kilometres as follows: ₦610.05/km for 151-350 and ₦328.18/km for above 500km. In the case of 0-50km, where the average transportation cost per average distance was ₦662.27/km (lower), the explanation may be the fact that some block manufacturers normally give a discount on transportation for certain ranges of distance. Others have a fixed charge per block in respect of distance of shipment.

Further information generated was that the average transportation cost per average tons shipped increased as the distance increased in kilometres: ₦823.99/tons for 0-50km, ₦4447.67/tons for 151-350km and ₦5200.00/tons for above 500km. The major findings were that the average transportation cost per average distance decreased as the distance increased, while the average transportation cost per average tons shipped increased with increases in distance per kilometre.

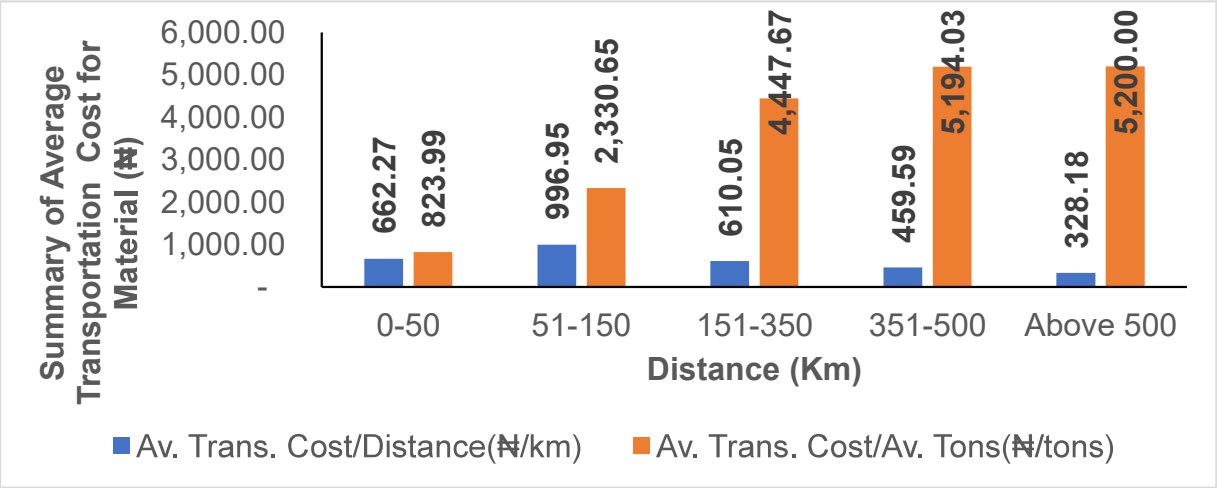

Figure 5.83: Summary of Average Transportation Cost of Material Per Average Distance Travelled

Source: Researcher's Field Survey (2019)

5.3.2 Analysis of Logistics Systems - Collaboration and Integration for MFC Sites 1-10

This study sought to identify the current logistics subsystems used by the construction material manufacturers, and to explore their level of collaboration and integration. The literature review revealed that logistics systems were classified into three phases: institutional criterion, flow criterion and functional criterion. This study focused on the current functional criterion utilised by the manufacturing companies. Collaboration and integration indicators were used to analyse the logistics systems. The analysis is presented in the next section.

5.3.2.1 Identification of Current Logistics Sub-systems

A systems concept is an analytical framework that seeks total integration of components essential to achieving stated objectives. Effective measurement systems must be constructed to accomplish the three objectives of monitoring, controlling and directing logistical operatives.

The identification of the current logistics sub-system is presented in Figure 5.84. It reveals that all (100%) of the manufacturers used the transport, material handling and order processing sub-systems. In addition, 70% of the companies used both warehouse and inventory sub-systems, while 80% used information technology and 40% used packaging sub-systems. The findings indicate that most of the companies utilised six out of the seven sub-systems. However, fewer than average of the companies used packaging sub-systems. This may be explained by the fact that the nature and type of some materials does not requires packaging. These include reinforcement bars, crushed stone, sand and hollow sandcrete blocks.

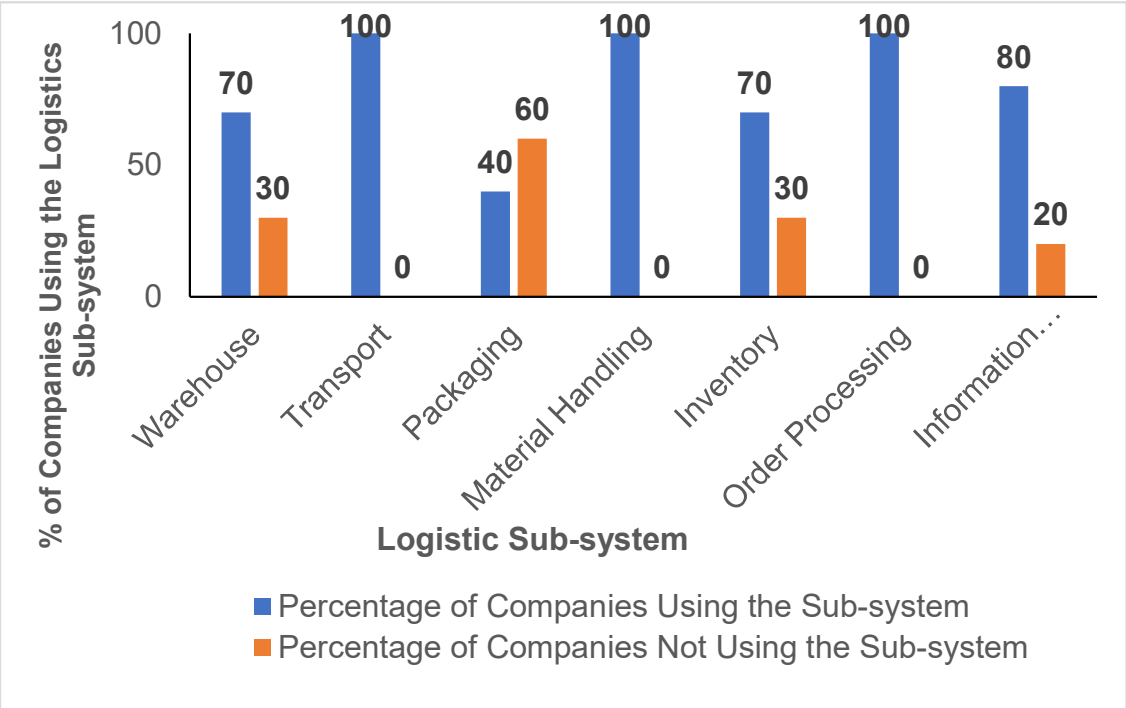

Figure 5.84: Identification of Logistics Sub-Systems
Source: Researcher's Field Survey (2019)

5.3.2.2 Logistics Systems Collaboration and Integration

The collaboration and integration indicators were used to evaluate the level of collaboration and integration of the manufacturing company's logistics systems. The result is presented in Figure 5.85. It reveals that 74% of the companies showed no collaboration, and 76% showed no integration. However, it was established that 26% of the companies indicated that there was collaboration, and 24% that there was integration in the sub-systems. This signifies that there was minimal collaboration and

integration of the sub-systems within most of the companies. Furthermore, the collaboration was within the functional departments, and not across the supply chain partners.

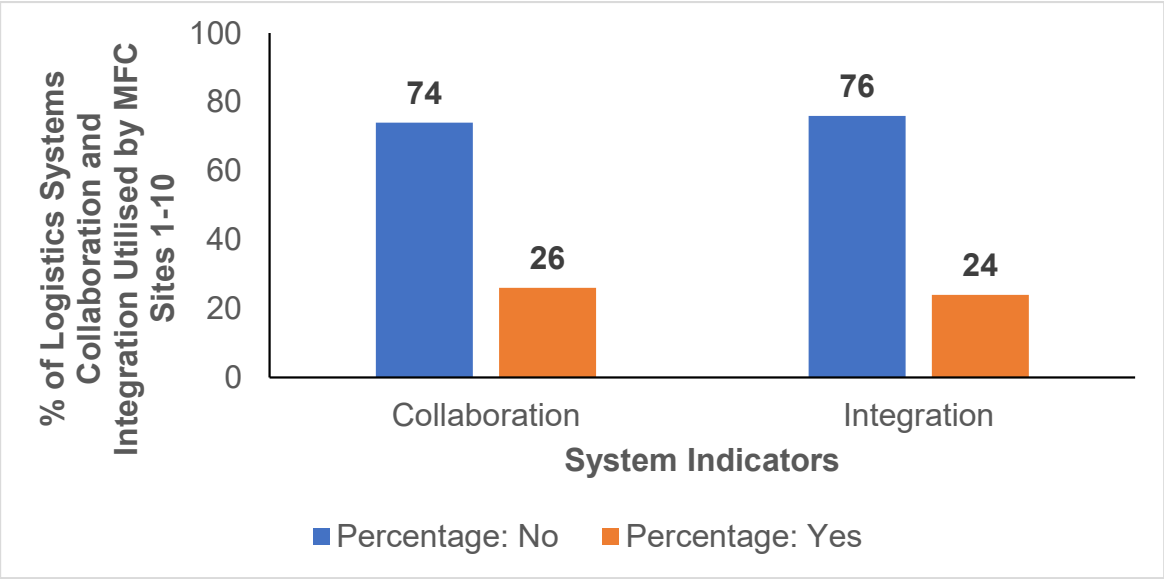

Figure 5.85: Logistics Systems Collaboration and Integration
Source: Researcher's Field Survey (2019)

5.3.3 Analysis of Manufacturer Warehouse Efficiency for MFC Sites 1-10

There are many interrelated decisions that need to be made and aligned for companies to be effective in warehouse operations. The inter-relationship between labour, technology, equipment and warehouse layout are discussed in Sections 3.7, 3.8 and 3.9. These reflect the criteria against which all operations must be measured for efficiency. It is against this background that the efficiency in manufacturer warehouses was evaluated in the next section.

5.3.3.1 Network Structures of Manufacturer Warehouses

This research study sought to understand the type of network structures used at the manufacturer warehouses. It revealed that 100% of the manufacturer warehouses adopted a break-bulk strategy, as shown in Figure 5.86. This means that bulk shipment was transported in FTL from the manufacturing plant to the DC/WHs Retailer Stores. Here, the materials are broken into smaller quantities (lots) and transported in LTL to smaller retail outlets or customers.

The chart in Figure 5.87 illustrates break-bulk warehouse transport structure. This signifies consolidation in transportation. Therefore, the economies of transportation were achieved by the manufacturing company warehouses.

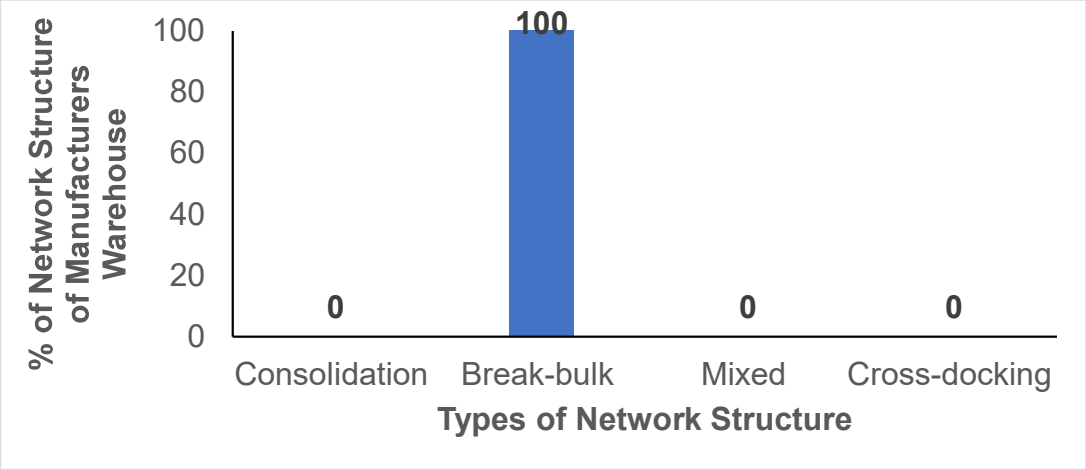

Figure 5.86: Type of Network Structures of Manufacturer Warehouses
Source: Researcher's Field Survey (2019)

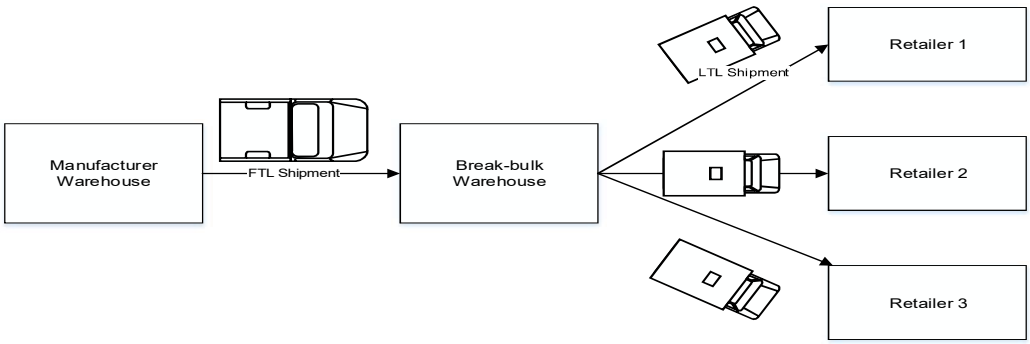

Figure 5.87: Network Structure for a Break-bulk Warehouse
Source: Modified from Ballou (1999)

5.3.3.2 Floor Sizes of Manufacturer Warehouses

Figure 5.88 provides graphically important evidence that 60% of the manufacturer warehouse floor sizes were between 501-3000m^2. A total of 20% of the manufacturer warehouse floor sizes were between 5001-7500m^2 and 10% were between 7501-10,000 m^2. In addition, most of the manufacturers warehouse buildings were 15.0m high, which is quite different from the 3.0m height observed in DC/WHs and retailers stores. This allows for the cube method space utilisation for both material storage and handling equipment. There was also an interesting finding that cement manufacturers had no warehouses (operate a zero-inventory strategy).

Crushed stones, hollow sandcrete blocks and sand are handled in open spaces. For sand, it was only two places where dredging and stockpiling was observed. In the remaining 10 sites, sand was sourced in its natural form. The major findings were that the majority (60%) of the sizes of warehouses for reinforcement bars and ceramic tiles were between 501-3000m.^{2} Cement companies do not operate warehousing systems. Crushed stones, blocks and sand used open spaces. The implication is that most of the companies have the capacity to hold a large stock of material to meet up with demand uncertainty.

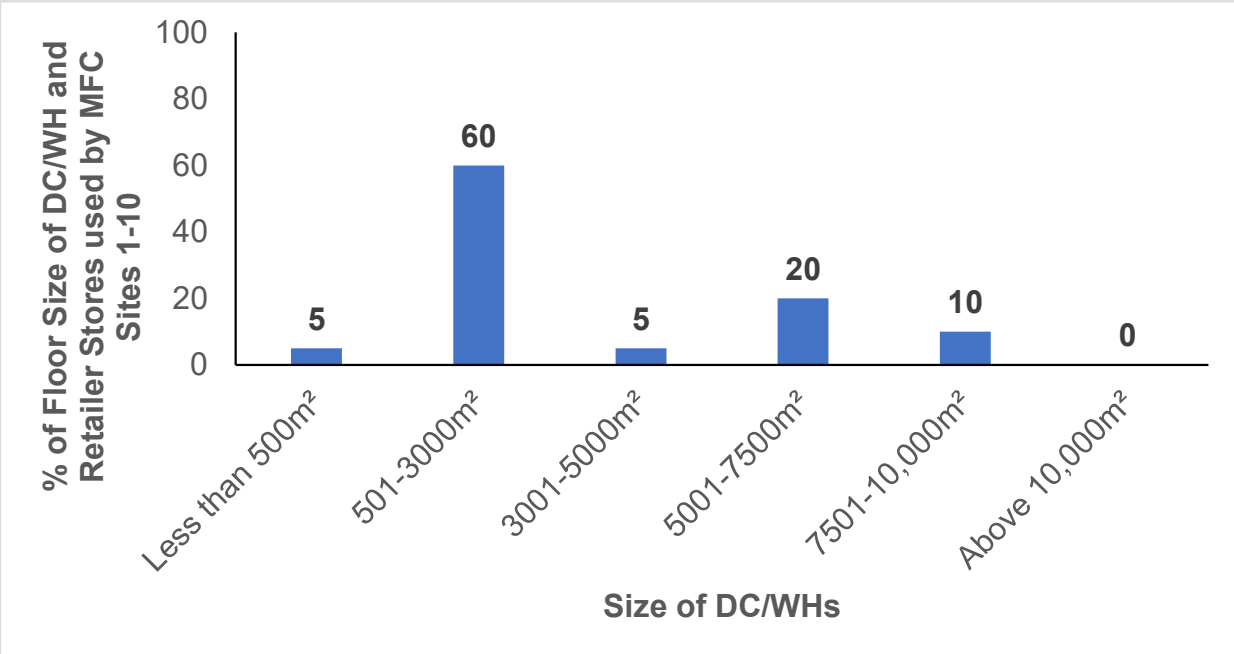

Figure 5.88: Floor Sizes of Manufacturer Warehouses
Source: Researcher's Field Survey (2019)

5.3.3.3 Demand and Supply of Material in Manufacturer Warehouses

The records of weekly orders received, processed and delivered to customers by the manufacturing companies were evaluated. Figure 5.89 presents the weekly quantities of material demanded and supplied to various locations. The information records revealed that the quantities supplied could not meet the orders that were demanded. The highest quantities demanded and supplied were recorded in Abuja, while the least quantities demanded and supplied were recorded in Lafia. In addition, it was established that only 77% of the total quantity demanded was supplied. This provided confirmation that the supply of material was sub-optimal. The implication is that the

market mediation cost, which relates to supply and demand, leads to either loss of sales or unsatisfied customers.

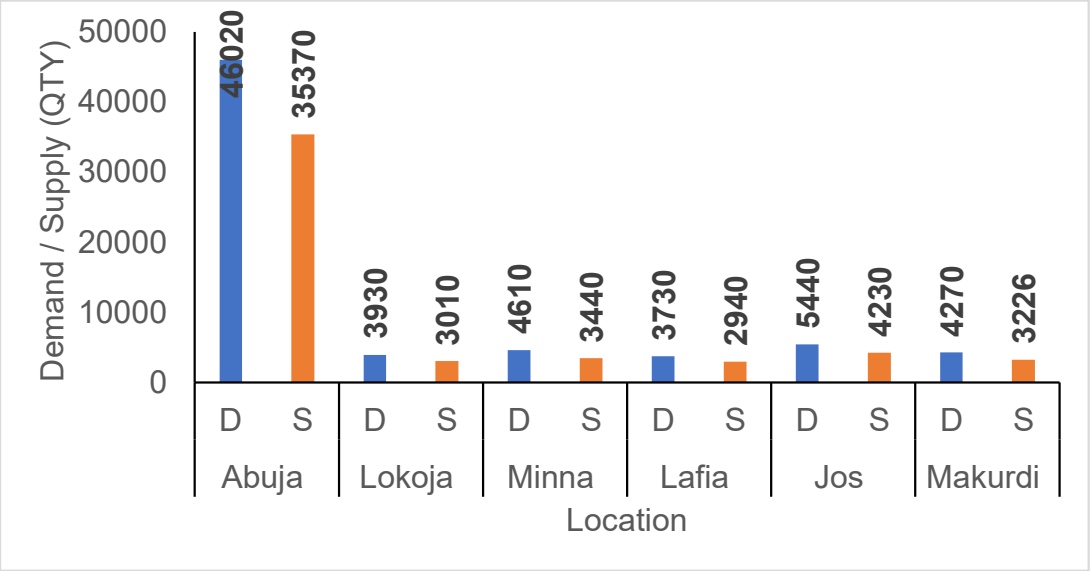

Figure 5.89: Demand and Supply of Material in Manufacturer Warehouses

Source: Researcher's Field Survey (2019)

5.3.3.4 Method of Packaging of Material

Packaging is among the primary target areas on which manufacturers focus to improve the efficiency of their transport operations. Therefore, this study sought to find out the method of packaging of material for transportation by the manufacturing companies.

Figure 5.90 presents the types of packaging of all materials in the warehouse for transportation. It revealed that 44% of the packaging was bulk, which represented crushed stones and sand materials. Other findings included 6%, for cartons and pallets for ceramic tiles; 6% for bags used for cement, and 6% for bundles of reinforcement steel bars. A total of 38% was for hollow sandcrete blocks, as they were transported without any form of packaging. It is important to note that though ceramic tiles used pallets for movement and storage in the manufacturers warehouse, they did not use them in transportation, limiting its benefit. The implication is that if the manufacturers used standard pallets, this would create a unit load to minimise transport and handling costs. It would also influence the utilisation of warehouse space.

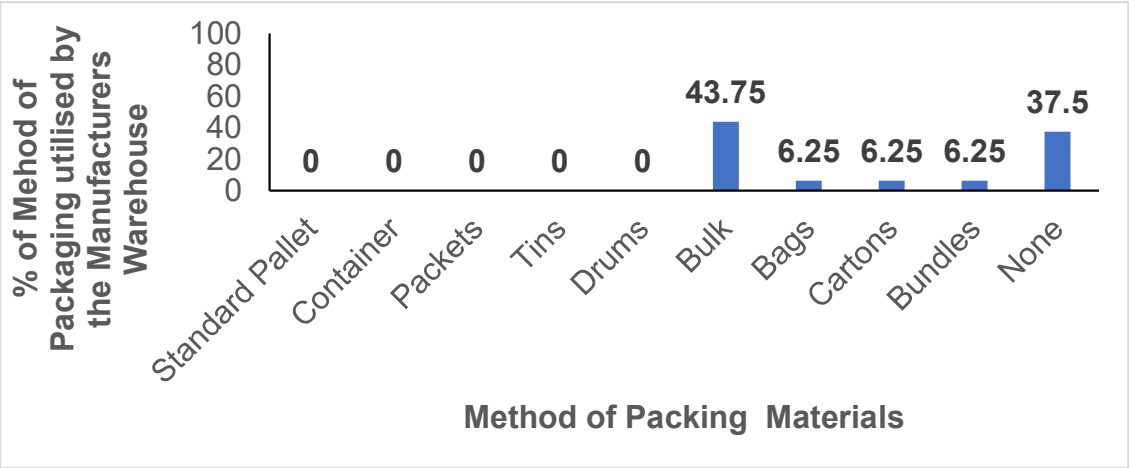

Figure 5.90: Method of Packaging Material in the Manufacturer Warehouse
Source: Researcher's Field Survey (2019)

5.3.3.5 Order Picking Method used in Manufacturer Warehouses

Picking is a central function of warehouse logistics. A vast number of options span the range between fully automated and manual picking systems. This section examines the different methods of picking used to attain the goals of reducing travel and waiting time.

Figure 5.91 presents the identification of current technology utilised for order picking processes in the manufacturer warehouses. This established that 88% of the companies used the paper picking method, while 12% use an automated method. The major finding was that most of the companies used the paper picking method, which suggests low adoption of technology.

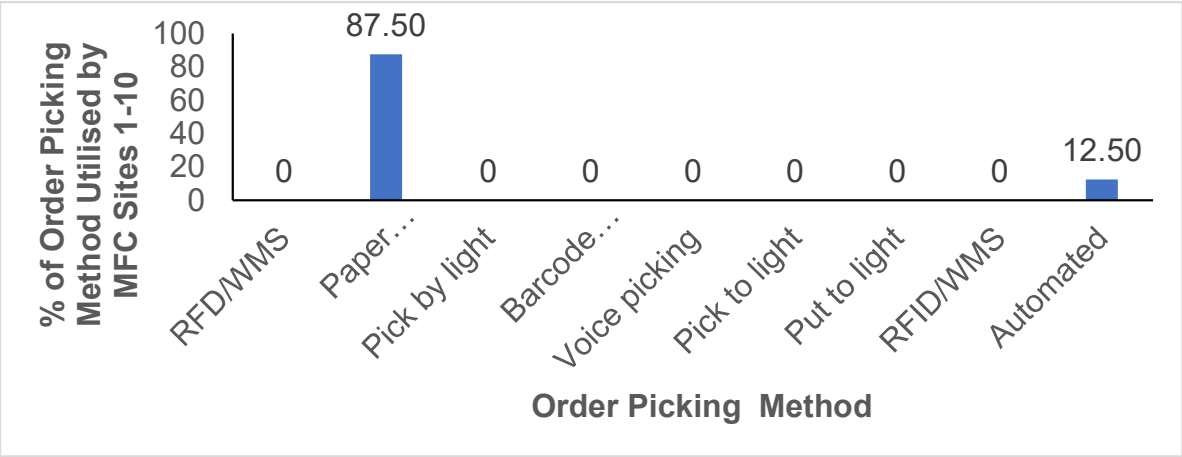

Figure 5.91: Order Picking Methods Adopted in the Manufacturer Warehouses
Source: Researcher's Field Survey (2019)

5.3.3.6 Material Handling Equipment used in Manufacturer Warehouses

A modified list of equipment for order picking used in the study by Baker and Perotti (2008:74) was adopted as the list of handling equipment for this research. Figure 5.92 indicates the type of material handling equipment utilised in the manufacturer warehouses. It established that 13% of the companies used a shovel loader, while 6% of the companies used mini automated loaders, high level order picking cranes and fork lift trucks. In addition, 69% of the companies did not use any of the order picking equipment. The major finding was that most of the companies did not use any of the material handling equipment. This suggests there was still a low take up of full automation of material handling processes by the manufacturing companies in their warehouses.

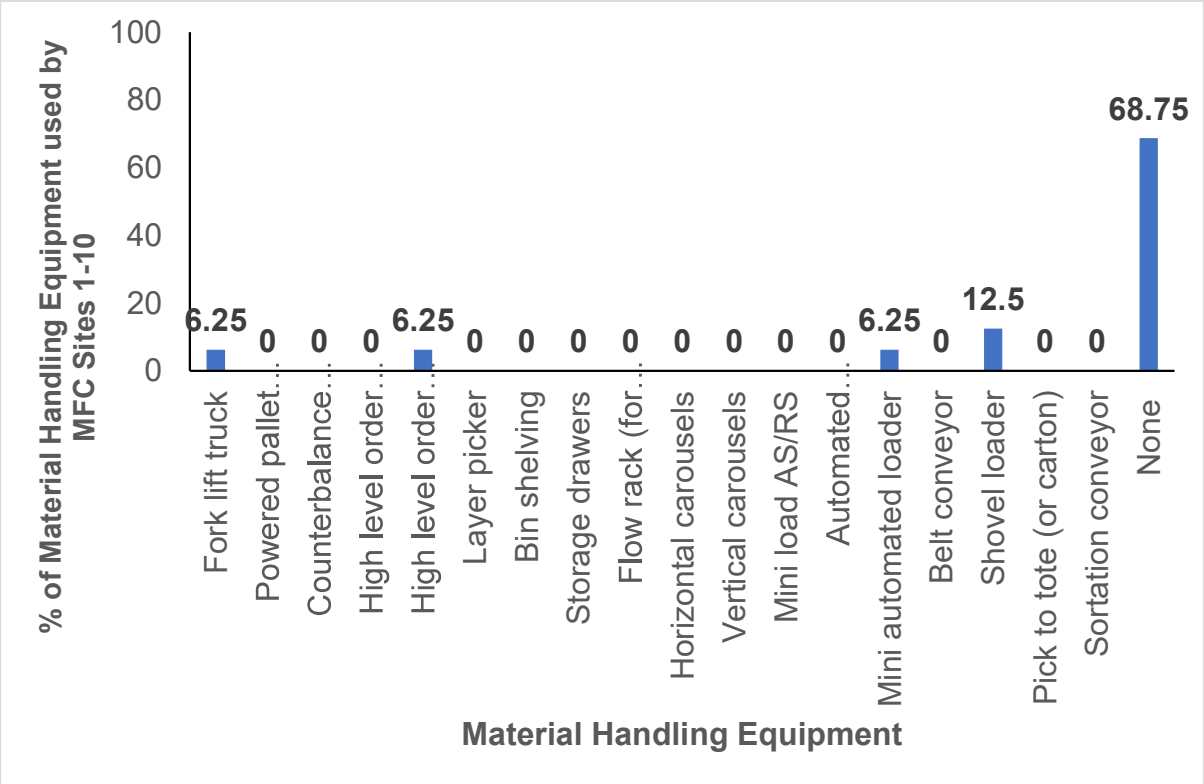

Figure 5.92: Material Handling Equipment used in Manufacturer Warehouses
Source: Researcher's Field Survey (2019)

5.3.3.7 Storage Equipment used in Manufacturer Warehouses

Pallet storage list of equipment used in a UK warehouse by Baker and Perotti (2008:72) was adopted as the list of storage equipment for this study. Figure 5.93 established that 88% of the companies used floor/ block, 6% used double deep and

6% used pallet floor racking storage equipment. The major finding was that most of the companies used the floor/block storage method, which suggests a low take up of pallet storage equipment in the warehouses. However, the most popular storage equipment was floor/block storage equipment, which is a cheap way to store robust products where there are many units per Store Keeping Unit (SKU). Nevertheless, there are advantages and disadvantages associated with floor block storage.

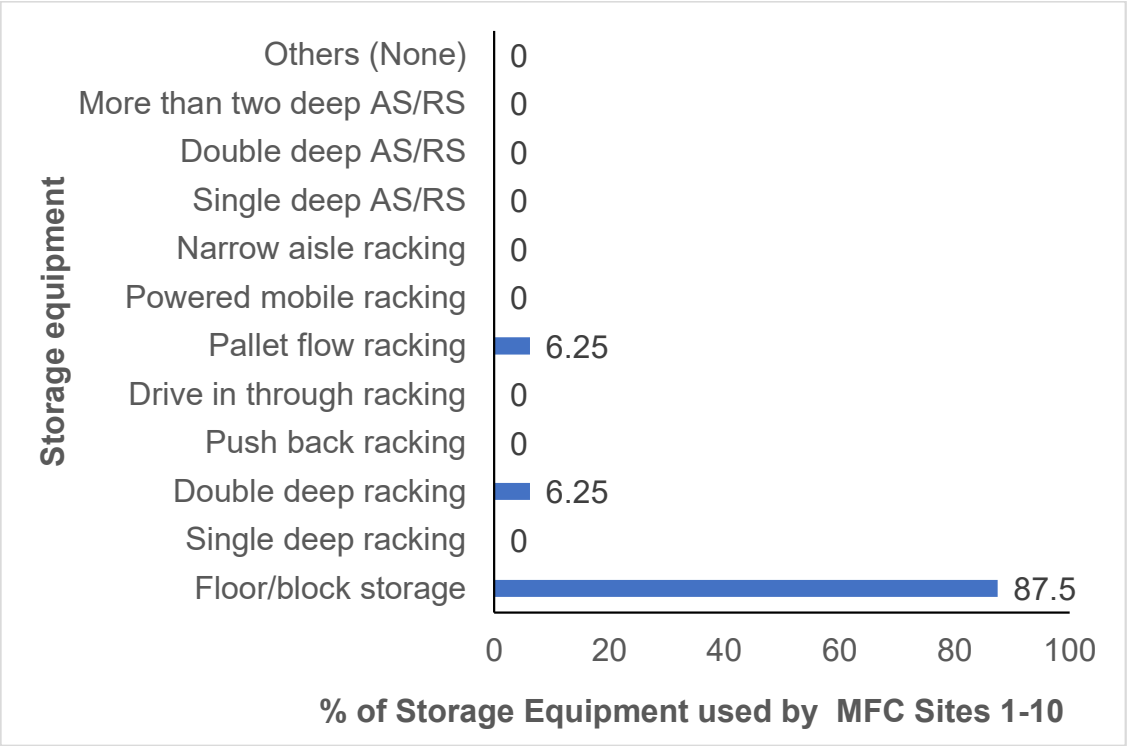

Figure 5.93: Storage Equipment Used in Manufacturer Warehouses
Source: Researcher's Field Survey (2019)

5.3.4 Analysis of Transportation Efficiency

In developing an understanding for the nature of material deliveries, it is essential to know the parameters of the flow of the logistics system under observation. Consequently, data needed to establish transportation efficiency of the construction material were collected. These included mode of transport, vehicle ownership, condition of vehicle, vehicle capacity, loading state of vehicle on arrival and departure, method of loading and offloading, loading and offloading time and cost, the dwell time on-site, vehicle technology and vehicle shipping efficiency. These descriptors were evaluated to determine transportation efficiency in this section.

5.3.4.1 Mode of Transportation

Figure 5.94 presents the mode of transportation being used for the delivery of construction material by the manufacturing companies. It shows that 100% of the companies use the road as the mode of transportation for delivery of materials to customers. Roads have remained the most significant means of transporting construction material to DC/WHs, Retailer stores and end-users in Nigeria. Though the road is not economical for haulage over long distances exceeding 350km, it has an average operational flexibility as vehicles can serve several purposes.

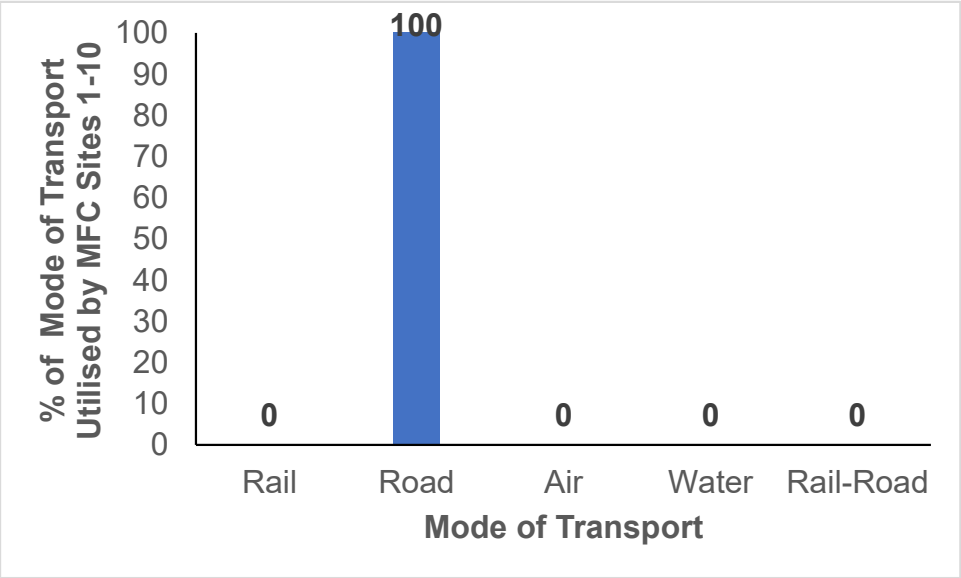

Figure 5.94: Mode of Transportation
Source: Researcher's Field Survey (2019)

5.3.4.2 Vehicle Ownership

Vehicle ownership is an important aspect of the outbound logistics systems because it enhances the movement of products over long distances and to various geographical regions. Therefore, this research study evaluated the type of ownership of vehicles used for material delivery by the manufacturing companies.

The chart in Figure 5.95 demonstrates the transport policy in terms of vehicle ownership operated by the manufacturing companies. The findings indicate that 65% of the vehicles were owned by third party transport providers. A total of 25% of the vehicles were owned by the manufacturers (cement companies, 1 ceramic company and block manufacturers). These were the only companies operating an in-house transport system. The significant finding is that most of the companies outsourced their

transport services. This may be connected to the fact the vehicle ownership continues to be a challenge to manufacturing industries because of the capital-intensive nature and requisite skill required to operate the transport system. More so, company managers preferred to focus on the production process and enjoy the requisite skills of third-party logistics providers.

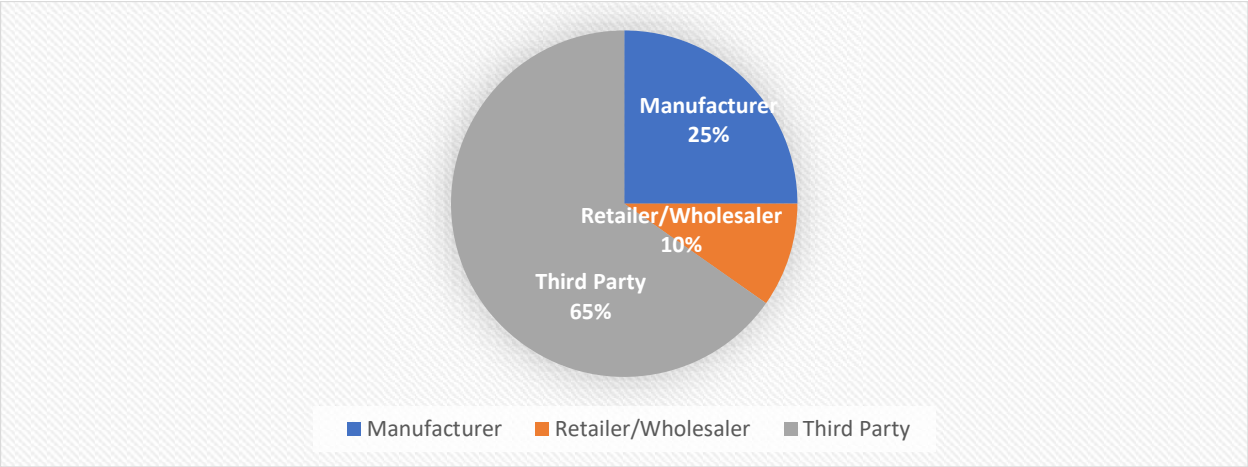

Figure 5.95: Vehicle Ownership used for Delivery of Material
Source: Researcher's Field Survey (2019)

5.3.4.3 Condition of Vehicles used for Delivery

The analysis of the condition of vehicles used for delivery is presented in Figure 5.96. The finding revealed that 73% of the vehicles were well maintained, 14% were of average condition, while 10% were in poor condition. This means the vehicles in poor condition were coming to the end of their lives. They will therefore require more maintenance cost or will be either scrapped or recycled. Furthermore, vehicles in a poor condition do break down and contribute to the disruption of delivery schedules, which might increase transit time and overall lead time.

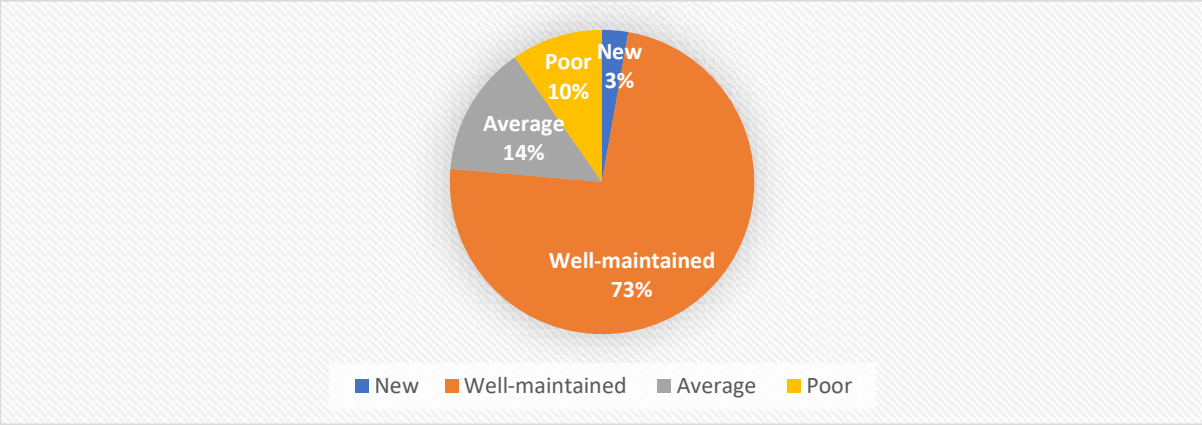

Figure 5.96: Condition of Vehicles used for Delivery
Source: Researcher's Field Survey (2019)

5.3.4.4 Vehicle Total Capacity

The capacity of freight trucks determined the quantity of materials or products to be carried. Therefore, the capacity of vehicles used for deliveries was analysed and the results presented in Figure 5.97. It showed that 50% of the vehicles used for delivery were of 30-ton capacity, while 14% of vehicles were 40 tons and 5 % above 45 tons. This signifies that most of the vehicles are designed to carry 30 tons and above, which is more economical to use for long distance haulage. The implication is that with load consolidation economies, distance can be achieved by minimising transportation cost. This is a significant finding in terms of optimum vehicle utilisation.

In addition, there was a substantial number of vehicles with capacities of 5, 10, 15, 20 and 25 tons. These types included tippers and smaller trucks used in the delivery of sand and hollow sandcrete blocks. These are mostly used for short distance deliveries which are sometimes in LTL shipment.

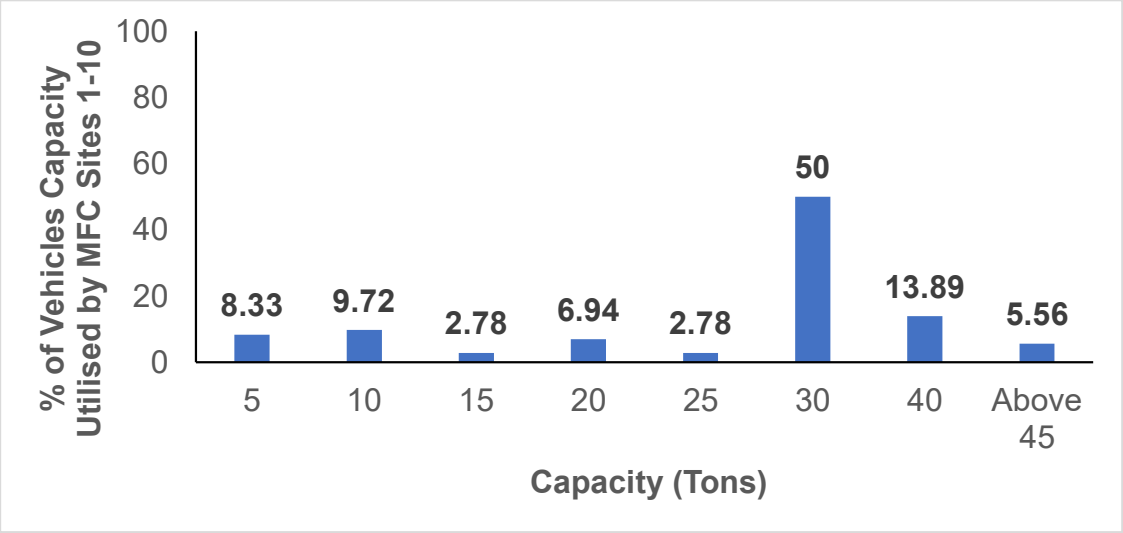

Figure 5.97: Vehicle Capacity
Source: Researcher's Field Survey (2019).

5.3.4.5 Combined Tonnage Loading State of Vehicle on Arrival and on Departure

The data on the state of a vehicle on arrival and on departure for loading gives statistics which are of huge importance. Figure 5.98 presents a graphical analysis of the tonnage loading state of vehicles on arrival at the manufacturer warehouse. It shows that 100% of vehicles arrive empty at a manufacturer's warehouse. In addition, the chart illustrates that a total of 94% of vehicles leave the manufacturer warehouses

in FTL; another 3% of vehicles leave the warehouses three-quarter full (LTL) and the other 3%, half full (LTL). The significance of these findings is that most of the vehicles depart from the manufacturer warehouses in FTL, which implies consolidation in transport.

The data presented demonstrated a close correlation to the primary arguments set down in this thesis, namely that returning vehicles travel empty to their company warehouses. It can be argued from this correlation that vehicles that departed fully loaded, thereafter also returned to these warehouse/plants completely empty. However, it must be noted that some of the third-party transport providers may have dropped off their original load at other depots/warehouses or sites. The implication is that the vehicle usage is approximately at 50% efficiency at best. This signifies gross underutilisation, thereby reducing vehicle shipment efficiency.

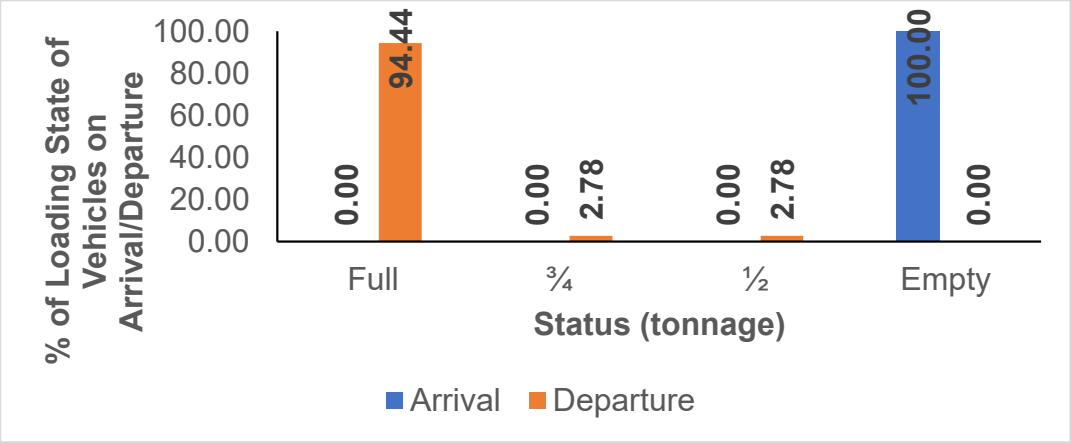

Figure 5.98: Combined Tonnage Loading - State of Vehicle on Arrival and on Departure
Source: Researcher's Field Survey (2019)

5.3.4.6 Method of Loading and Offloading Vehicles

The Dwell Time (DT) of vehicles is crucial to the efficiency of the transport sub-system of the logistics system, as earlier discussed in Section 3.6.3. This is to understand the need for maximising of immediate and continuous utilisation of vehicles. To address this, data were collected on seventy-two orders that were processed and delivered. Data included the method of loading and offloading, the number of trucks loading at a time, loading and offloading period, loading and offloading time and cost. The analysis of the data is presented in the next section.

There was a need to reveal first the level of automation adopted to increase productivity and efficiency in loading and offloading of vehicles. Data on the method of loading vehicles at the manufacturer warehouses were recorded. Data was also recorded on the offloading of vehicles at the DC/WHs, Retailer stores and Sites. These data were analysed and presented in Figure 5.99.

The analysis results indicated that 40% of the companies used manual methods of loading at their warehouses and sites. Companies used shovel loaders (16.67%), forklift trucks (14.29%), high level cranes (14.29%) and automatic loaders (14.29%) to load material. The major finding was that more than half (60%) of the company warehouses were automated.

In addition, the findings established that 75% of DC/WHs, Retailer stores and Sites used manual methods of offloading material. A total of 25% used the tipping method, which was basically for sand and parts of crushed stones. It was also observed that trailers were used to transport crushed stones. Since they cannot tip off, the material was manually offloaded. The major findings were that 60% of loading at the manufacturer warehouses was automated or semi-automated, and 40% was manual. Offloading at the DC/WHs, Retailer stores and Sites was 75% manual and 25% tipping.

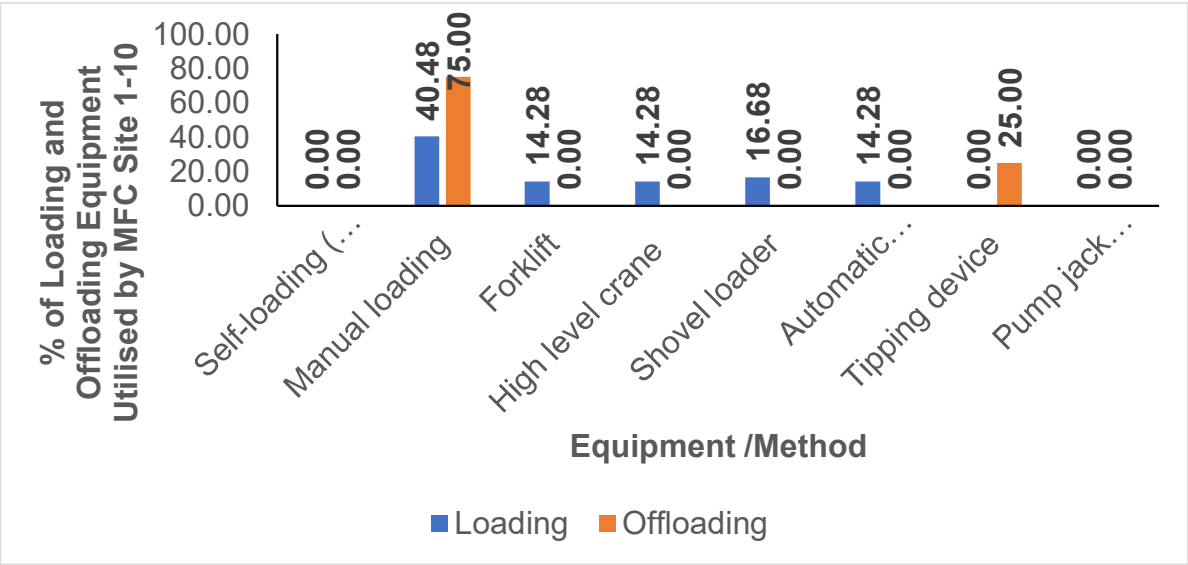

Figure 5.99: Method of Loading and Offloading of Vehicles
Source: Researcher's Field Survey (2019)

5.3.4.7 Number of Vehicles Loading at a Time

Data were collected on the number of vehicles that could be loaded at a time. This was to verify if there were queues due to congestion at the dock or loading bay of the plants, as this may also create waiting time.

The result of the analysis of vehicle loading at a time is presented in Figure 5.100. It was established that 37% of the company dock bays have a capacity for 1-3 vehicles loading at a set time. Also, 21% of dispatch bays have the capacity for 4-6 vehicles; 31% for 7-10 vehicles and 6% for 11-15 vehicles loading at a time. This established that 58% of the manufacturer dock bays have the capacity for more than four (4+) vehicles at a time. There was no traffic congestion observed at the company dispatch bays. This suggests that most of the time losses were not connected to congestion at the loading bay but could have been caused by other factors such as administrative issues or inefficiency in the system.

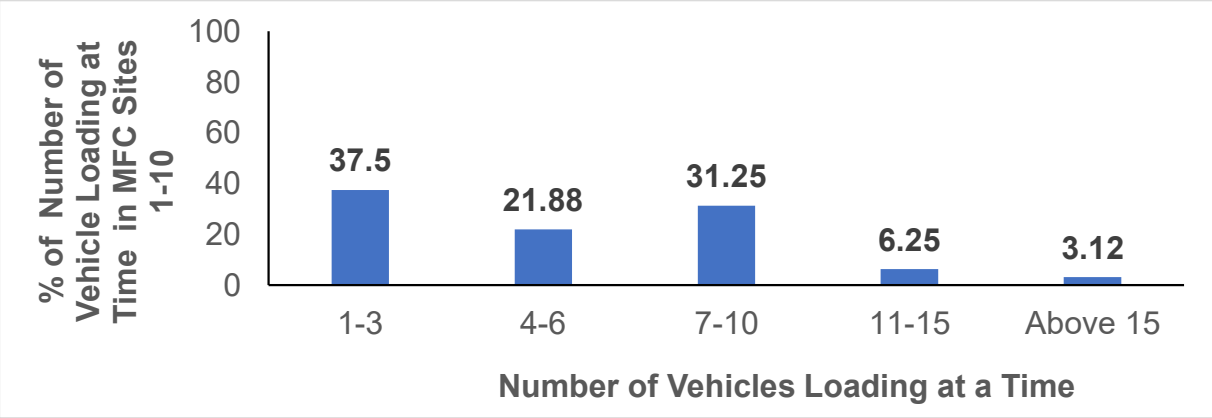

Figure 5.100: Number of Vehicles Loading at a Time
Source: Researcher's Field Survey (2019)

5.3.4.8 Period for Loading and Offloading Vehicles

The loading and offloading period for vehicles, before being dispatched to their next destination, is also important to this study. How much time a vehicle waited in the manufacturer warehouse before loading was observed and recorded.

Figure 5.101 indicates that 75% of the manufacturing companies load vehicles between 08:00–18:00 hours (10 hours), which was during working hours only. The significant finding was that most of the company loading time was ten (10) hours out of the twenty-four (24) hours per day. As a result, any vehicle which arrived at the

plants/ warehouses after 18:00 hours had to wait till the next morning before they could be loaded. They had to wait all through the night. The implication of this is that there is a longer vehicle Dwell Time (DT) between 18h00-08h00, which is a 14 hours difference. This reduced the vehicle utilisation, thereby increasing lead time. A total of 8% of the blocks/sand companies loaded between 06h00–08h00, and 17% of cement companies for 24 hours. It was observed that only cement companies loaded for 24 hours per day.

The results confirmed that 81% of the DC/WHs and Retailer Stores had an offloading period between 08:00-18:00, which are the normal business hours. As earlier explained, all vehicles that arrived after closing time had to wait till the next day to be offloaded. This also increased vehicle DT by 14 hours. Some 9% of the DC/WHs and Retailer Stores offloaded their materials between 06h00– 08h00 and 8% between 18h00–22h00. These are basically block and sand companies, which sometimes work a little beyond normal working hours as their point of discharge is not constrained by law for offloading. This is unlike for other materials, which are normally offloaded in the market area. Most of the construction material markets have a fixed opening and closing time. This limits operations to between working hours of 08h00 –18h00. The consequence is underutilisation of vehicles during operational hours due to a longer dwell time of fourteen (14) hours per day at each, or both, terminals. However, most of the vehicle drivers would have preferred travelling during the night.

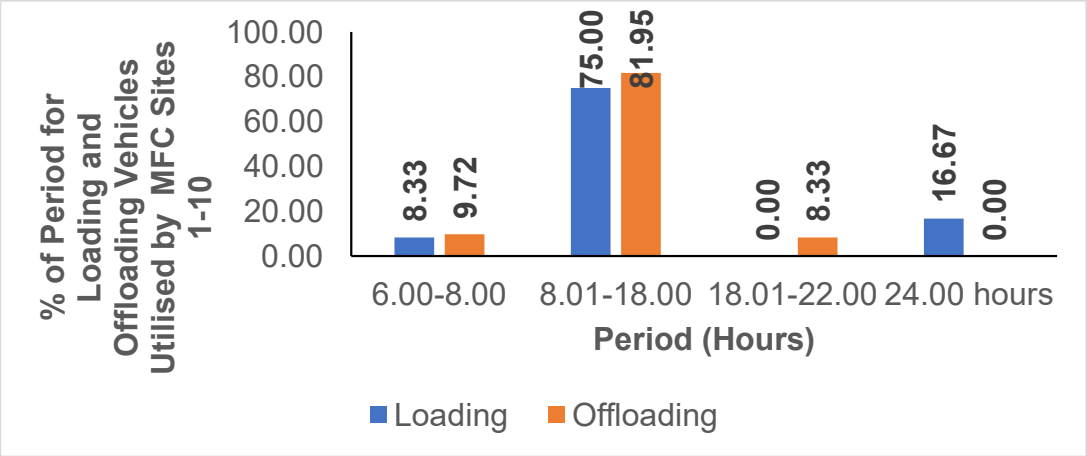

Figure 5.101: Period for Loading and Offloading Vehicles
Source: Researcher's Field Survey (2019)

5.3.4.9 Loading and Offloading Time

The economies of density are enhanced by using high capacity technology to handle large bulk loads and minimising loading and offloading time. Therefore, the time of loading and offloading individual materials at the terminals was evaluated.

The analysis of the average time taken to load and offload material per ton is presented in Figure 5.102. It was confirmed that, for cement, the loading time was 0.02 hours/ton and offloading time was 0.11hours/ton. Records confirmed the average loading and offloading time for reinforcement bars (0.04 and 0.18 hours/ton), ceramic tiles (0.07 and 0.17hours/ton) and crushed stones (0.01 and 0.07hours/ton). It is interesting to note that crushed stones offloading time is higher than its loading time. This is because trailer trucks were also used in the delivery of crushed stones. Since they do not tip off, the material had to be manually offloaded, which led to increased offloading time and cost. The implication is that time costs are non-value-added costs: this cannot be recovered when one does an invoice for a load of material.

The major finding is that materials which were loaded mechanically (automated) took up less time than when they were offloaded manually. However, the blocks that were manually loaded and offloaded did not show much disparity in time. Sand (which is mostly manually loaded and mechanically tipped off) had a higher loading time than offloading time.

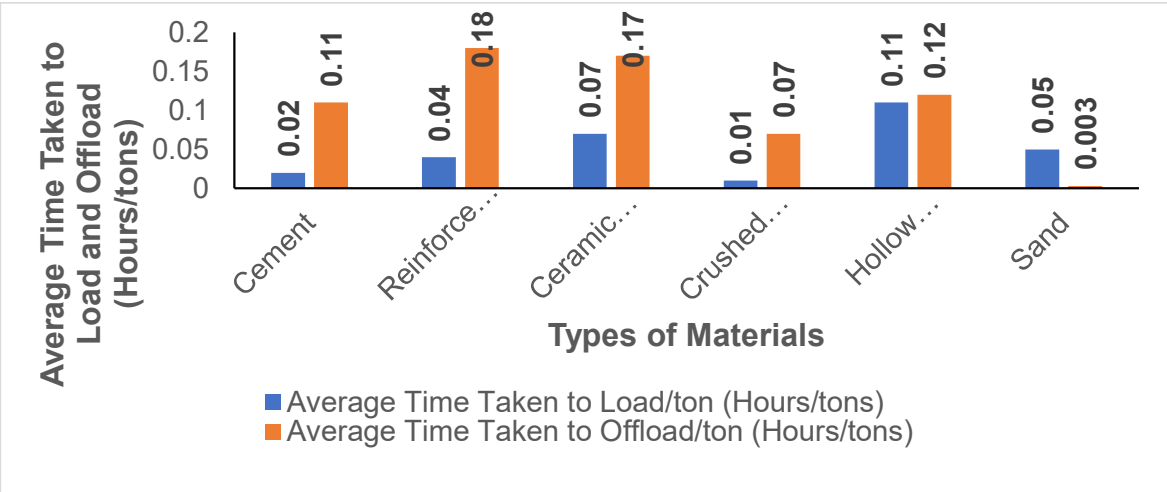

Figure 5.102: Average Time taken to Load and Offload Materials Per Ton
Source: Researcher's Field Survey (2019)

5.3.4.10 Cost of Loading and Offloading Material

The time taken for loading and offloading of construction material was analysed. However, it also has cost implications. The cost of loading and offloading individual materials at the terminals was thus evaluated. Each time a material is handled, either manually or by a machine, the touch time cost goes up.

The correlation of average cost to load and offload individual material is shown in Figure 5.103. The results confirmed that the average cost of loading per ton was as follows: cement (₦56.62/ton), reinforcement bars (₦425.63/ton), ceramic tiles (₦507.99/ton), crushed stones (₦78.16/ton), blocks (₦179.73/ton) and sand (₦151.66/ton).

In addition, the chart reveals that the average cost of offloading was as follows: for cement (₦274.70/ton), reinforcement bars (₦861.24/ton), tiles (₦537.31/ton), crushed stones (₦150.07/ton), blocks (₦179.37/ton) and sand (₦25.53/ton). The average cost of offloading reinforcement bars per ton was the highest, probably because this involves offloading, bending and stacking them. However, it should be noted that ceramic tile companies used both fork lift trucks and manual labour when loading at the manufacturer warehouses.

The major finding was that the average cost of offloading materials/ton was higher than the average cost of loading, except for blocks and sand. This may be explained by the fact that blocks are both loaded and offloaded manually. The cost of loading sand is higher because most companies did this manually, but they offloaded mechanically.

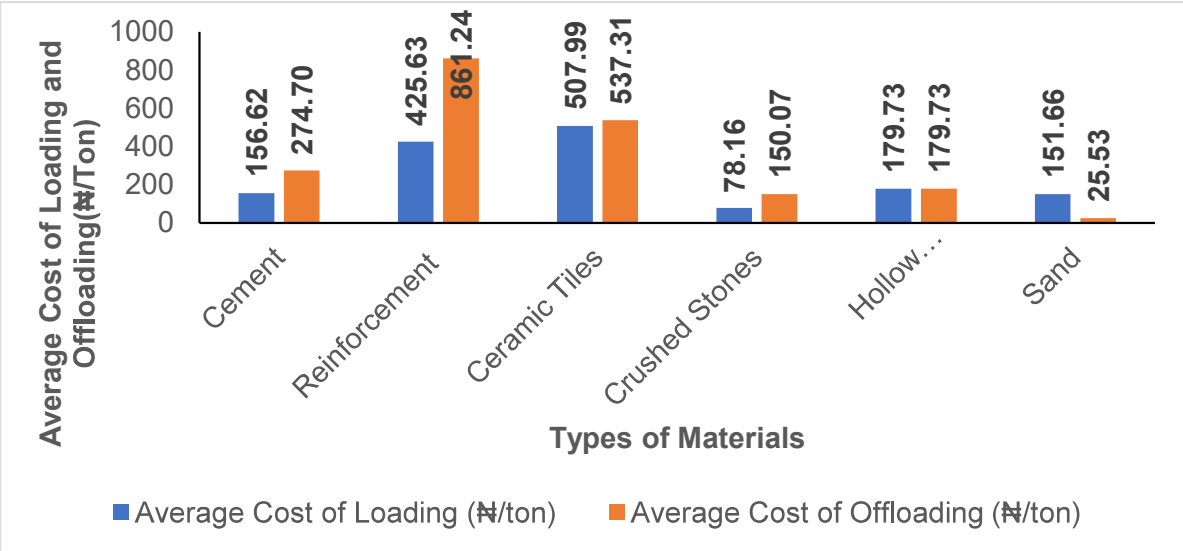

Figure 5.103: Average Loading and Offloading Cost Per Ton
Source: Researcher's Field Survey (2019)

5.3.4.11 Efficiency of Vehicle Usage

Transport consolidation is expected to result in larger overall shipment and thus increased vehicle utilisation. To provide a complete view of vehicle utilisation, three indicators are recommended by Vidalakis and Sommerville (2013:473):

- Vehicle Shipping Efficiency (VSE)
- Vehicle Journey Efficiency (VJE) and
- Vehicle Weighted Efficiency (VWE).

Refer to Section 3.6.4 for their explanation. Shakantu (2005 :268) adds Vehicle Utilisation Efficiency (VUE). However, it is when a delivery is part of a multi-drop run that lead time must account for turnaround times at the various preceding delivery locations. Delays at any point can greatly affect the reliability of successive deliveries. For this study, the delivery was taken to be one drop, and not a multi-drop run. Therefore, VJE and VWE could not be computed because there were no preceding delivery locations with turnaround times. Thus, only VSE and VUE were analysed in this study.

VSE refers exclusively to the initial loading condition of the vehicle, without considering any vehicle movement characteristics. It is particularly useful since it is a major determinant of the vehicle dispatch criterion. Indeed, allowing for a maximum lead time

that a company aims to achieve, vehicles with high VSE are more probable to be dispatched than vehicles with low VSE.

VSE can be calculated using VSE = ADo ÷ PDo × 100, where

ADo is a vehicle's Actual Overall Delivery, and

PDo is a vehicle's Potential Overall Delivery.

Calculating VSE= ADo ÷ PDo × 100

=1925÷1980×100

VSE = 97.22%.

On the other hand, the formula used to establish Vehicle Loading Efficiency (VLE) is given by: % [(ADf/PDf) +(ADr/PDr)] x 100, where

ADf is for Actual Delivery on the forward journey;

PDf is for Potential Delivery on the forward journey;

ADr is for Actual Delivery on the return journey, and

PDr is for Potential Delivery on the return journey.

Delivery is measured by quantity of truck loading i.e. Full, 3/4,1/2, l/4, Empty, and potential delivery is taken to be 100% or 1.

VLE=% [(0÷1980) + (1925÷ 1980)] × 100

= % [9.722] × 100

=9.722÷100× 100

VLE = 9.722

Alternatively,

VLE= % [(320÷ 1980) + (1605÷ 1980)] × 100

= % [(0.16162) + (0.81060)] ×100

= % [0.9722] × 100

= 0.9722÷ 100× 100

VLE = 9.722

Table 5.14: Vehicle Utilisation Efficiency (VUE)

Sources: Manufacturer plants/ sites	No. of Vehicles	Vehicle's potential overall delivery (Vehicle total capacity) tons PDo or PDf or ADr	Vehicle's actual overall delivery (Total tonnage at departure) ADf		Vehicle's actual overall delivery (Total tonnage at departure) ADr or ADo	
MFC Site 1	6	250	0	125	250	125
MFC Site 2	6	220	0	80	220	140
MFC Site 3	6	180	0	0	180	180
MFC Site 4	6	190	0	0	190	190
MFC Site 5	6	180	0	30	180	150
MFC Site 6	6	180	0	0	180	180
MFC Site 7	6	215	0	0	215	215
MFC Site 8	6	220	0	0	220	220
MFC Site 9-20	12	125	0	85	85	0
MFC Site 21-32	12	220	0	0	205	205
Total	**72**	**1980**	**0**	**320**	**1925**	**1605**

Source: Researcher's Field Survey (2019)

The loading data for all manufacturing company deliveries are presented in Table 5.14, where VSE was calculated using equations. The average VSE for construction materials was 97.22%. The result implies that it is more probable that the vehicles are being dispatched because of high VSE value.

However, in the computation of the vehicle loading efficiency, which incorporated the back hauling (reverse journey), the computed value of average VLE was 9.72%. From vehicle loading efficiencies obtained, it can be deduced that the vehicles are under-utilised in terms of their movement.

5.3.4.12 Technology used in Vehicles

Technology in vehicles is required to integrate the transport sub-system with the warehousing sub-system and customers. This is to improve efficiency, and for monitoring and tracking the load in transit. This forms the basis for which data were collected on the types of technology installed in the vehicles.

Figure 5.104 indicates that 87% of the vehicles used for the shipment of construction material do not have any of the identified technology installed in them. Some 7% of

the vehicles had a material tracker, and 6% a speed limit tracker installed in them. This signifies that most of the vehicles do not have any of the technology installed in them. This further implies that the transport system is not linked to manufacturer plants, DC/WHs, Retailer stores and construction Sites.

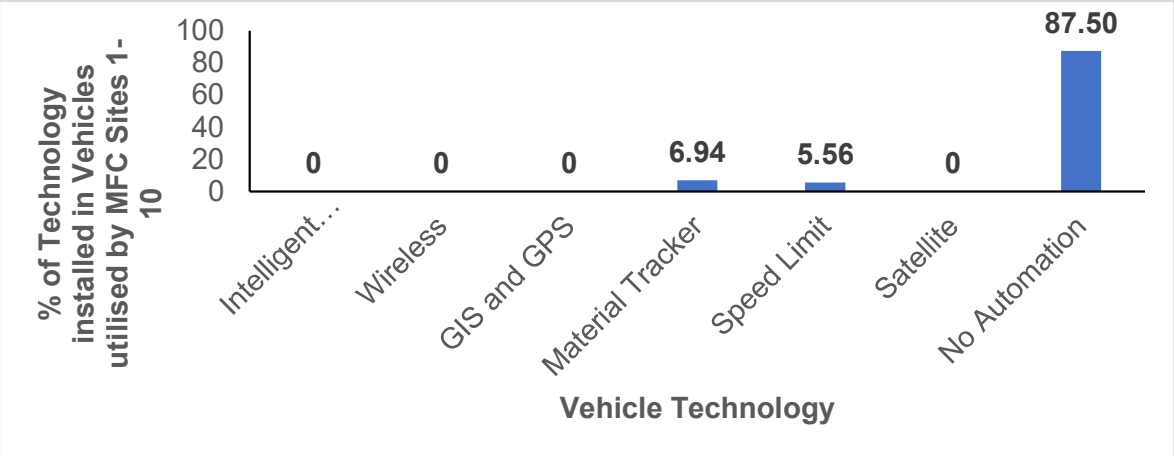

Figure 5.104: Types of Technology Installed in Vehicles
Source: Researcher's Field Survey (2019)

5.3.5 Technology Adoption in the Logistics Process

Technology is the key driver to improving the overall effectiveness and efficiency of a logistics system. This formed the crux of this research study, as the fifth research objective focused on evaluating the level of technology adopted in the logistics processes utilised by Nigerian construction material manufacturing industries. This section presents the analysis of data on the level of technology, namely of AutoID technology, communication technology, Information technology and e-business in logistics operations as adopted by Matopoulos,Vlachopoulou and Manthou (2009:6) and Bhandari (2013:20).

5.3.5.1 Adoption of Automatic Identification Technology (Auto ID)

This analysis is aimed at understanding the level of use of new automatic identification technology tools in logistics processes by the construction material manufacturers. Figure 5.105 illustrates that 100% of the companies do not adopt AutoID tools in their logistics operations. This finding implies that most of the processes of data capturing and information flow are manually done, suggesting low productivity.

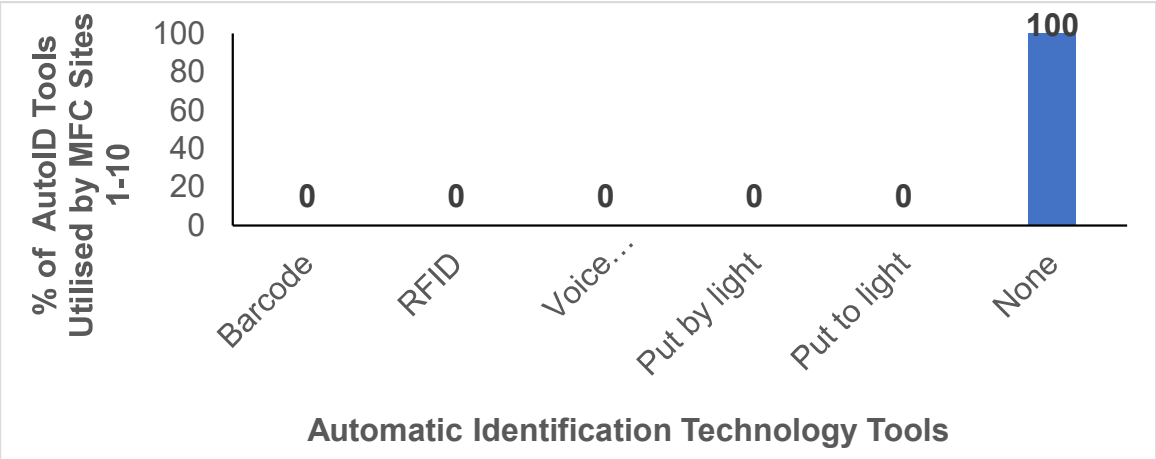

Figure 5.105: Auto ID Technology Tools Adoption in Logistics Processes
Source: Researcher's Field Survey (2019)

5.3.5.2 Adoption of Communication Technology Tools

Figure 5.106 indicates the level of adoption of communication tools in logistics operations by construction materials manufacturers. It confirmed that 8% of the companies adopt GPS and GIS, while 6% were Web-based. Some 78% of the companies did not adopt any of the communication tools in logistics operations. This is a very low level of adoption of communication tools. However, it was observed that the few companies that used GPS, GIS and Web-based for tracking and monitoring their vehicles did so to achieve vertical communication between Headquarters, plant, drivers and distribution centres. The technology was also not aimed at horizontal communication with other logistics partners.

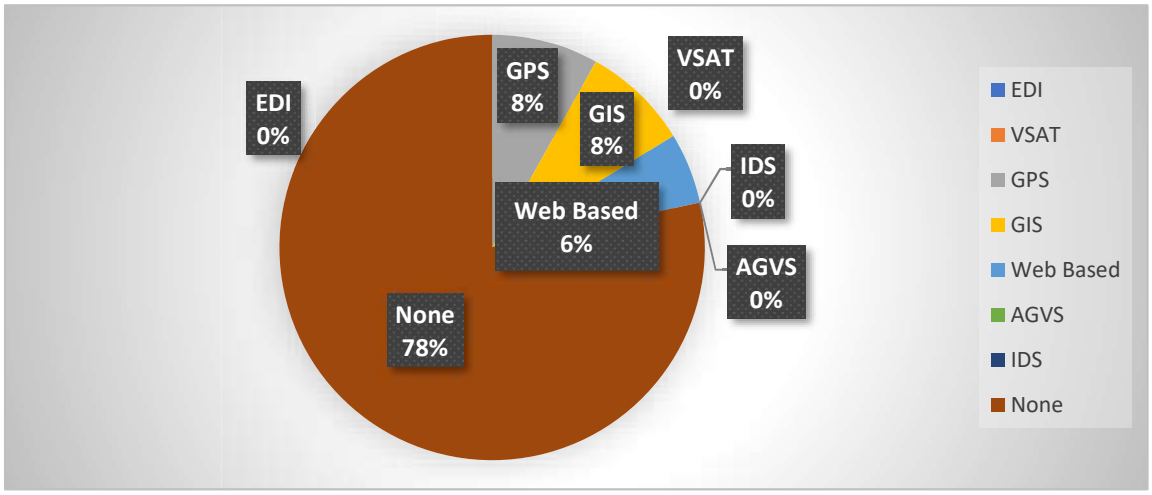

Figure 5.106: Adoption of Communication Technology Tools in Logistics Operations
Source: Researcher's Field Survey (2019)

5.3.5.3 Adoption of Information Technology Tools

The analysis of the adoption of information technology tools is presented in Figure 5.107. The findings show that 6% of the companies adopt ERP in logistics operations, while 94% do not use any of the information technology tools. This indicates a low level of adoption of information technology tools in logistics operations by the construction material manufacturing industries. The findings suggest that the benefit of using technology to improve efficiency and effectiveness in logistics is not being achieved.

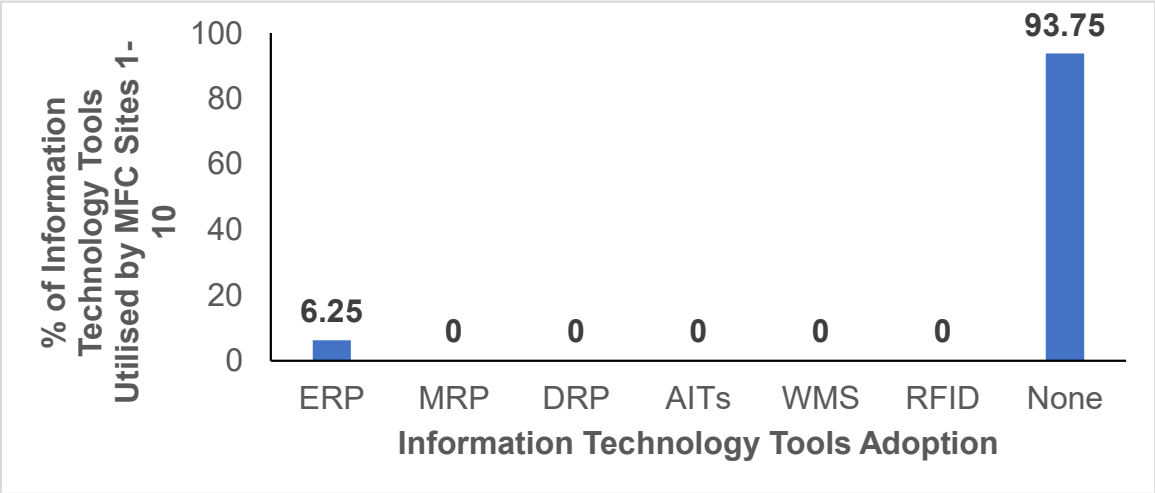

Figure 5.107: Adoption of Information Technology Tools in Logistics Operations
Source: Researcher's Field Survey (2019)

5.3.5.4 Adoption of E-Business Tools

Figure 5.108 presents the level of adoption of e-business tools by the companies. The analysis revealed that 25% of companies used both internet and e-banking in logistics operations. The Web-based tools were adopted by 9% of the companies, while 75% did not use any of the e-business tools. The findings indicate a very low adoption of e-business tools in logistics processes by the construction materials manufacturers. However, they used both internet and e-banking for payment and receiving credit alerts by the companies. This does not provide for information sharing, or for partnership/collaborations with other stakeholders in the logistics system.

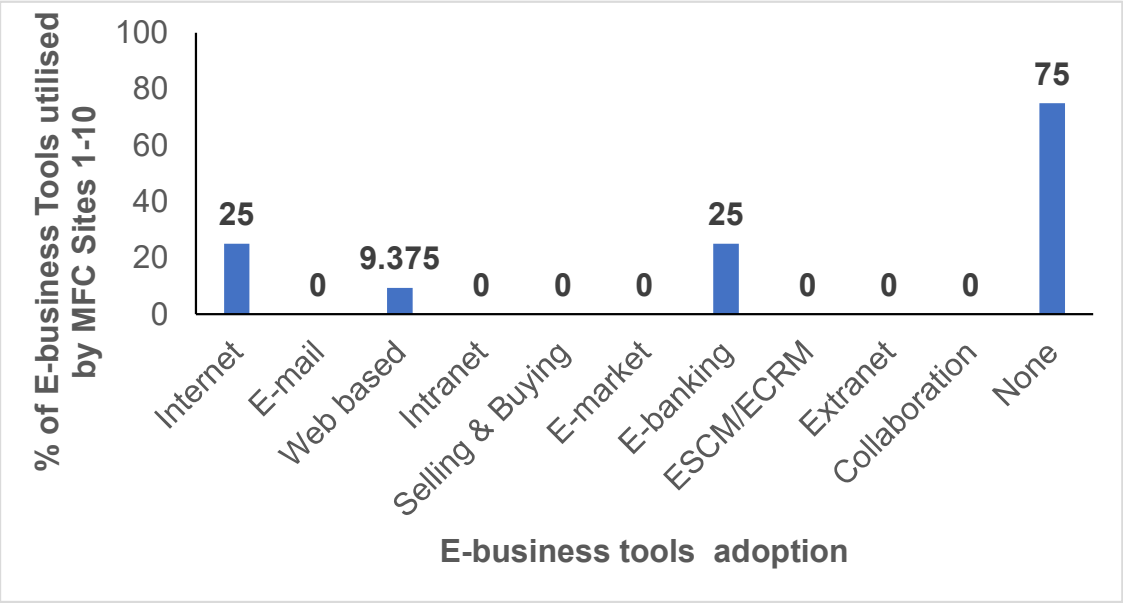

Figure 5.108: Adoption of E-Business in Logistics Operations
Source: Researcher's Field Survey (2019)

5.3.6 Assessing the Efficiency of Warehouse Processes from a Customer Satisfaction Perspective

Understanding warehouse performance measurements is critical to achieving successful outcomes. Section 4.7.4 of this study revealed that the current performance of a company provides the starting point for potential service improvement. Therefore, to analyse the efficiency of warehouse processes from a customer satisfaction perspective, it was necessary to collect data pertaining to the problem itself. This study adopted four out of the five most popular customer-based measures identified by WERC (2010:142), as discussed in Section 3.13. The four metrics adopted for this study were:

i. On-time delivery;
ii. Internal order cycle time in hours;
iii. Total order cycle time in hours; and,
iv. Order picking accuracy.

Perfect Order Completion Metrics include the following: On time delivery, in full delivery, damage free and accurate documentation, labelling and invoicing. These are measured individually and then multiplied together to produce the perfect order percentage (Gwynne, 2014:304).

i. On-time delivery is usually measured by dividing orders delivered on time by the total number of orders delivered. The goal to achieve ratio of 100% is ideal.
ii. Damage measurements include the percentage of items picked that are undamaged when received by the customer, and the percentage of orders picked without damaged merchandise (Ecklund, 2010:14).
iii. Service measures include a fill rate which is based on the number of orders that were filled completely (Ecklund, 2010:14).
iv. Order accuracy is the calculation of orders picked and dispatched accurately, divided by total orders received x 100.
v. Internal cycle order time is the measure of elapsed time from issue of the order receipt until the order is ready for shipment (Ecklund, 2010:6).
vi. Total order cycle time is the measure of elapsed time from order receipt until the customer receives the products (this includes transportation or transit time) (Ecklund, 2010:6).

Benchmarking is the process of improving performance by continually identifying, understanding and adapting outstanding practices and processes found inside and outside the organisation. Benchmarking seeks to improve any given business process by exploiting "best practices" rather than merely measuring the best performance. Best practices are the cause of best performance. Therefore, the four Quintile Benchmarks customer metric by WERC (2010:142) was adopted to analyse order cycle time and the perfect order completion index.

Table 5.15 presents a guide to reading the Benchmark Quintile report, while Table 5.16 is the four-customer metric used for this study. It is presented in a 7 column “Quintile” format that is intended to shed light about how companies are performing.

Table 5.15: A Guide to Reading the Benchmark Quintile

A Guide to Reading the Benchmark Quintile Reports						
Metric	Major Opportunity	Disad-vantage	Typical	Advantage	Best in Class	Median
This represents the metric that is being examined (metrics definitions can be found in the complete WERCWatch report)	*QUINTILE RANKINGS* These columns split all data responses into 5 equally divided groups. Each quintile ranking indicates 20% of the responses, with the 5 groups divided categories representing					This indicates the actual median performance of all respondents
	Represents the lowest 20% of responses	Represents responses ranging in the 20-40th percentile	Represents responses ranging in the 40-60th percentile	Represents responses ranging in the 60-80th percentile	Represents top 20% of all responses	

Source: Peter, Karl and Vitasek (2008:9)

Table 5.16: Four Customer Quintile Benchmark Metrics

Customer Metrics	Major Opportunity	Disadvantage	Typical	Advantage	Best in class	Median
On-time shipments	Less than 96%	>= 96 and <98.3%	>=98.3 and <99.5 %	>=99.5 and <99.8%	>=99.8 %	99%
Damage free	Less than 95%	>= 95 and < 98%	>= 98 and < 99%	>=99 and <99.5%	>=99.5 %	98.9%
Total order Cycle time	Greater than 72Hours	>=28.9 and < 72 Hours	>=24 and <28.9Hours	>=8 and <24 Hours	<8Hours	24Hours
Internal order cycle time	Greater than 27.4 Hours	>=21.2 and <27.4 Hours	>=8 and <21.2Hours	>=3.4 and <8 Hours	<3.4Hours	12Hours
Perfect order completion index	Less than 85%	>=85 and <91.1%	>=91.1 and <98%	>=98 and <99.3%	>=99.3 %	96%

Legend: > greater than; >= greater than or equal to; < less than

Source: WERC (2010:142)

Data needed to establish customer satisfaction were collected. These included the number of orders delivered on time and in full, quantities of material delivered damage free, orders filled accurately, internal order cycle time, transit time and total order cycle time. This information was crucial to this study as it addressed the effectiveness of the logistics system, which centres on customer satisfaction. The next section presents an analysis of the perfect order completion indicators, order cycle time and customer-based metrics gap.

5.3.6.1 Analysis of Perfect Order Completion Indicators

Table 5.17 shows the data, while Table 5.18 presents the calculation of the perfect order fulfilment indicators. It was confirmed that 66.67% of the orders were delivered on time, and 100% of the orders were shipped in full. Order fill rate was 100%, and order accuracy was 100%. Some 92.79% of orders were delivered free of any damage. The major findings were that two thirds (67%) of the customers received their orders on time, and a majority (93%) of the materials were received free of any damage.

Table 5.17: Perfect Order Completion Indicators

Indicator	No of order	Total orders
On time delivery	48	72
Order fill rate	72	72
In full delivery	72	72
Order accuracy	72	72
Damage free delivery	92.79%	100%

Source: Researcher's Field Study (2019)

Table 5.18: Analysis of Perfect Order Completion Indicators

Indicators	Calculation	Value
On Time Delivery	**Orders On-Time / Total Orders Shipped x100**	**66.67 % on-time deliveries**
In Full Delivery	**Orders shipped complete/ Total order shippedx100**	**100% in full deliveries**
Order Fill Rate	**Orders Filled Complete / Total Orders Shipped x100**	**100% complete deliveries**
Order Accuracy	**Error-Free Orders / Total Orders Shipped x100**	**100 % deliveries are error-free**
Orders Received Damage Free	**% of Items received undamaged by customer /Total items shipped to the customer**	**92.79%**

Source. Researcher's Field Survey (2019)

A summary of perfect order percentage was computed. The four indicators were measured individually (computed earlier in Table 5.18), then multiplied separately to get the Perfect Order Percentage.

Perfect Order Percentage= On time x in full x Order fill rate x Order accuracy x Orders received damage free÷100000.

= 66.67x 100 x 100 x100 x 92.79÷ 100000

= 61.86 %

The summary of the computation of the Perfect Order Percentage index was 62%. When compared to Customer Quintile Benchmark Metrics, it was less than 85%. This indicates a *Major Opportunity for Improvement.*

5.3.6.2 Order Cycle Time

Order cycle time is a critical measure to determine service and efficiency. This is comprised of internal order cycle time and total order cycle time (WERC 2010:142; Ecklund, 2010:6). The order cycle time data was recorded for a total of seventy orders received by the manufacturing companies. These were then processed and delivered to the various locations within the study area.

The data was captured as follows:

- Firstly, the date, time and quantities of an order received by the manufacturing company was recorded.
- Secondly, the date and time when the order was completely processed (including time taken up to loading of the vehicle for shipment) was recorded.
- Thirdly, the date and time of departure of the vehicle from the manufacturing company warehouse, and its destination for delivery was recorded.
- Fourthly, the date and time the vehicle arrived at the destination; or when customers received the delivery at the DC/WHs, Retailer stores and construction Sites was recorded.

Thereafter, the internal order cycle time, transit time and total order cycle time were computed for each of the seventy-two orders. The analysis of the internal order cycle time and total order cycle time follows:

- **Internal Order Cycle Time**

Table 5.19 presents the analysis of the internal order cycle time using the WERC Quintile Performance Metrics benchmark (2010:142). It shows that internal order cycle times were: 87.5% (Major opportunity), 6.94% (Disadvantage), 2.78% (Typica), 2.78% (Advantage) and 0% (Best in class). The verbal descriptors here would be *Major*

Opportunity, Disadvantage, *Typical* and *Advantage*. They indicate that most internal order cycle time records were within the *Major Opportunity for Improvement* descriptor, and by implication performing far below *Best in Class* <3.4 hours.

In addition, it established that the internal order cycle time Mean was 84.20 hours, and the Median was 77.53 hours. This indicates that the internal order cycle time median was greater than 12 hours. As per the WERC Benchmark, this implies a Major *Opportunity for Improvement* of the process.

Table 5. 19 : Internal Order Cycle Times

Quintile Performance Metrics for determining internal order cycle time by WERC	No. of orders processed	Percentage of 72 deliveries
Major opportunity >27.4 Hours	63	87.5
Disadvantage >= 21.2 and 27 Hours	5	6.94
Typical >= 8 and < 21.2 Hours	2	2.78
Advantage > =3.4 and 8 Hours	2	2.78
Best in Class < 3.4 Hours	0	0
Total	72	100
Mean		84.20 hours
Median		77.53 hours

Source: Researcher's Field Survey (2019)

- **Total Order Cycle Time.**

Table 5.20 indicates the analysis of total order cycle time using the WERC Quintile Performance Metrics benchmark (2010:142). It shows that Total order cycle time were: 68.06% (Major opportunity), 20.83% (Disadvantage), 4.17% (Typical), 5.50% (Advantage) and 1.38% (Best in class). The verbal descriptors here would be for *Major Opportunity, Disadvantage*, *Typical* and *Advantage*. The significant finding was that most total order cycle times were within *Major Opportunity for Improvement* and by implication, performing far below *Best in Class* <8hours.

The total order cycle time Mean was 103.34 hours, and the Median was 95.14 hours. This indicates that the total order cycle time median was greater than the WERC benchmark of 24 hours, suggesting *Major Opportunity for Improvement* of the process.

Table 5.20: Total Order Cycle Times

Quintile Performance Metrics	No. of orders processed	Percentage of 72 deliveries
Major opportunity >72 Hours	49	68.06
Disadvantage >= 28.9 and 72 Hours	15	20.83
Typical >= 24 and < 28.9 Hours	3	4.17
Advantage > =8 and 24 Hours	4	5.50
Best in Class < 8 Hours	1	1.38
Total	72	100
Mean		103.34 hours
Median		95.14 hours

Source: Researcher's Field Survey (2019)

5.4 Chapter Summary

Chapter 5 presented the research data collated for this study. The data were analysed and interpreted. Chapter 5 included the results of archival records of transactions, the field observations and measurement templates on logistics processes and operations of the Nigerian construction material manufacturers.

The basic information presented in this chapter was intended to build up an understanding of the parameters of effective and efficient construction materials logistics processes on the ground, using the data from the sites examined. Chapter 6 presents a summary and discussion of the research results.

Chapter 6: Summary and Discussion of the Research Results

6.1 Introduction

Chapter 6 summarises the research results presented and interpreted in Chapter 5 of this study, and also relates the results to the findings in the literature review. The efficiency and effectiveness of Management-CMLS is the crux of this thesis, as issues of logistics affect efficiency of construction operations and cost.

The study investigated the order processing procedures and operations related to the delivery of materials from manufacturer warehouses to DC/WH, Retailer Stores and construction Sites. It included the use of a field study method comprising the analysis of 10 sites in North-Central Nigeria, using a standard observation and measurement procedure designed for this purpose.

Chapter 6 builds this understanding and shows the relationship that occurs between the data and objectives that were formulated. Consequently, the following discussion addresses each objective that was set out in Chapter 1.

Research Objectives

Objective 1: To identify and examine the current logistics channels utilised by the Nigerian construction material manufacturers.

Objective 2: To identify the current logistics systems utilised in Nigerian construction material manufacturers.

Objective 3: To analyse the efficiency of warehouse processes applied to construction material manufacturers in North-Central Nigeria.

Objective 4: To evaluate the efficiency of transportation being used for the delivery of construction material from the manufacturer plants to distribution warehouses, retailer stores and construction sites.

Objective 5: To determine the level of technology being used in logistics processes by the Nigerian construction material manufacturers.

Objective 6: To evaluate the level of customer satisfaction for the delivery of construction material from the manufacturer plants to distribution warehouses, retailer stores and construction sites.

Objective 7: To develop a framework for efficient and effective construction material logistics management.

6.2 Logistics Channels

Research Objective 1: To identify and examine the current logistics channels utilised by the Nigeria construction material manufacturers.

This section summarises and discusses the results relating to identification and examination of the current logistics channels utilised by the Nigerian construction materials manufacturers.

6.2.1 Logistics Channels

The review of the related literature in Section 2.12 revealed that there are currently six logistics channels that can be used, independently or in combination with each other, by manufacturing companies to deliver materials to customers (End- users). These identified logistics channels are as follows:

- Manufacturer (Producer)-Consumer (End user);
- Manufacturer-Retailer-End-user;
- Manufacturer- Distribution Centre/ Warehouse-Retailer-End-user;
- Manufacturer-Broker/Agent-Distribution Centre/Warehouse-Retailer-End-user;
- Manufacturer-Building Merchants and Material Suppliers-End-user; and,
- Omni-channel.

Having identified the current logistics channels, the study sought to find out which of these channels were used by the Nigerian construction material manufacturers. The study established that most construction materials manufacturers used multiple alternative logistics channels for the delivery of materials to customers. A minimum of two, and maximum of three channels were used by all manufacturers. Therefore, it can be deduced that all the manufacturing companies used multiple or combined logistics channels for their logistics operations. This findings corroborate Gwynne's (2014:41) conclusion that companies are increasingly delivering via multiple channels to reach customers more effectively. Each channel has its own benefits.

In addition, the direct-sales strategy channel is gaining popularity (Dangote Cement PLC, 2014:1). It has a high response time (Chopra, 2003:129) and also reduces cost and lead time. The condition of this channel is the minimum order quantity (for instance, cement is 30 tonnes or 600 bags), as this limits the affordability by individuals. However, it provides an opportunity for handlers of bigger construction projects to purchase, thereby cutting off the mark-up to the cost of materials by the intermediaries and reducing the lead time.

6.2.2 Location and Number of DC/WHs, Retailer Stores and Sites

The results established that half the number of DC/WHs, Retailer stores and Sites are in Abuja. It can therefore be inferred that the market here is larger because there is more construction work in the area. This confirms the assertion by Ecklund (2010:14) that, in addition to transportation costs, the location of DC/WHs is based on the availability of major markets and customers. When the warehouse is located close to several demand points or retailers, then scale of economies and stability of demand are easier to achieve (Apte and Viswanathan, 2000: 298).

There is no doubt that multichannel retailing is influencing the number and size of locations in operation (Gwynne, 2014:20). From a micro perspective, the effectiveness of logistics depends on the time and distance relationship between the nodes of the system, such as BM and MS proximity to construction sites (Vidalakis, Tookey and Sommerville, 2011:73).

6.2.3 Floor Size of DC/WHs and Retailer Stores

The study sought to find out the floor sizes of the DC/WHs and Retailer stores to establish their capacity for large stockholding to meet customer demand. The finding was that the floor size of the majority of the DC/WHs and Retailer stores was less than 500 square metres. The implication is that an arrangement must be made for frequent deliveries to the DC/WHs and Retailer stores to ensure availability of material. Therefore, it can be deduced that the sizes of DC/WHs and Retailer Stores were too small and hence had limited capacity for large stockholding. For instance, most of the cement DC/WHs and Retailer Stores could take only 600 bags of cement (30 tonnes).

In contrast, Milan (2013: 98) suggested that it does not matter whether a warehouse or distribution centre size is 1000 square metres or 500 000 square metres. It is essential to cut costs and to improve operating efficiency. However, there is an ongoing debate as to whether companies are going to increase the floor size or decrease the number of warehouses operating within the supply chain (Gwynne, 2014:20). A study by Motorola (2013:14) showed that while some planned to increase the number of warehouses, others preferred to increase the floor size of their existing facilities. However, there is a need for a trade-off between number and floor size of the DC/WHs and Retailer stores per location.

6.2.4 Network Structures used in DC/WHs and Retailer Stores

The study investigated the type of network structure used in the DC/WHs and Retailer Stores. The findings revealed that the majority of the DC/WHs and Retailer Stores were of mixed network structure. This result was supported by Apte and Viswanathan (2000:293) and Bowersox *et al.* (2013:226) that a mixed warehouse combines the methods of both consolidation and break-bulk warehouses. This point was earlier discussed in Section 3.7.3, while consolidation of transportation benefits was further supported by Hoff *et al.* (2010:2041) and Pienaar (2016b:419) in Sections 2.4.3.2 and 3.6.2.2 of this thesis. This is important because transportation economies and product variety can be obtained by using the mixed structure warehouse.

6.2.5 Distance Between Manufacturer Plants and DC/WHs and Retailer Stores

The analysis for each individual company (cement, reinforcement bars, ceramic tiles and crushed stones) established that most distances from manufacturer plants to DC/WHs, Retailer stores and Sites was between 0–350 kilometres. This agreed with Khooban's (2011:118) recommendation of a road transport range of 350km as ideal for achieving economies of transport for long distance haulage. However, if road distance is beyond the 350km, rail road intermodal transport becomes more economical than road transport. This correlation becomes progressively more expensive if the distance increases above 500km (Pienaar, 2016c:390). Moreover, the distance between the manufacturer and the end customer determined the amount of stock to be held in the warehouse and distribution centres. The trade-off here was between more expensive local suppliers and producers, and increased costs in transport and inventory holding costs (Gwynne, 2014:13).

The results revealed that most block manufacturers and sand suppliers were between 0-50km distance away from the construction sites. This finding was similar to the results of a study by Saka and Mudi (2007:784), that most suppliers of selected materials were located between 5 and 10km from the construction sites. The distances from manufacturers would be critical to Management-CMLS in view of the chaotic transport system in the cities. Traffic congestion, bad roads and man-hour loss on roads during shipping add to cost as well (Saka and Mudi, 2007: 784).

6.2.6 Distance and Cost

The study established that four out of six of the averaged transport costs (calculated for materials) per average distance were above ₦500/km. Half of the material average transportation cost per average ton was above ₦5000/ ton. This supported the claim that high transport and freight costs had been identified as the factors responsible for price increases in construction material in African countries such as Nigeria, Uganda and Kenya (Mathews, 2009:12; Mwijagye, 2010:44). Moreover, the conclusion, as noted by Sinclair, Artin and Mulford (2002:23), was that cost of materials increased primarily because of increased transport charges.

The data analysis revealed that the average transportation cost per average distance decreased as the distance increased per kilometre. This is in agreement with Pienaar's (2016c:381) assertion that the economies of distance would be attained when total transport cost per kilometre decreased as the trip distance increased. This would invariably reduce the price of material, thereby reducing the cost of any construction project. Economies of distance can be achieved by the fact that with an increase in the travelling distance, there would be fewer fixed costs such as load/offload cost, and admission tax in cross docking (Motraghi, and Marinov, 2012:73; Pienaar, 2016c:381). Andrejić and Kilibarda (2016:138) nonetheless advised that though distance driven, and the quantity of goods delivered in tons form important information for transport management, these major drivers have not been sufficiently studied for more conclusive, researched evidence.

The implication of the finding is that the normal view of economies of scale is that it lowers its long run production cost per unit, in transport expressed as cost per ton-kilometre. Contributing to scale of economies is the spreading of fixed over extended

output capacity example, fixed costs spread over increased fleet output capacity. Fixed overhead costs , time-bound corporate management-related costs common to all the activities of a firm remain constant within certain ranges of fleet size (Pienaar 2016c:377).

6.3 Evaluation of Logistics Systems Utilised by the Construction Materials Manufacturers

Research Objective 2: To identify the current logistics systems utilised by Nigerian construction material manufacturers.

This section identifies the current logistics systems utilised by the manufacturing companies and determines the level of collaboration and integration within and outside the systems.

6.3.1 Identification of Logistics Systems

The review of the related literature in Sections 2.2.4, 2.2.5, 3.3.1 and 3.3.2 revealed that logistics systems are classified into three phases: Institutional Criterion, Flow Criterion and Functional Criterion. This study focused on the current functional criterion used by the manufacturing companies. The identified functional sub-systems were warehouse, transport, inventory, packaging, order processing, information technology and material handling.

The identification of the current logistics sub-systems revealed that most of the manufacturing companies in North-Central Nigeria used the transport, warehouse, material handling, order processing and inventory subsystems. Half of the companies did not use the packaging system, which may be explained by the nature of the material. These are crushed stones and sand in bulk form, and hollow sandcrete blocks. All of these are transported without packaging.

A major finding was that five out of the seven logistics sub-systems were fully adopted by the manufacturing companies. It can be thus inferred that most of the identified logistics systems were used by the manufacturing companies. This finding agrees with the assertion by Gleissner and Femerling (2013:18) and Jaradat *et al.* (2017:4) that a logistics system is a purpose built and connected set of components or sub-systems. The sub-systems are linked together as an integrated system. This produces results

that are greater than those achieved through individual performance (Bowersox *et al.*, 2013:351).

6.3.2 Logistics Systems Collaboration and Integration

The analysis of collaboration and integration among logistics systems revealed that only a few of the manufacturing companies had any collaboration and integration. The collaboration that was observed occurred between the functions within a company, but not across boundaries between firms in a supply chain. Therefore, it can be deduced that there was minimal collaboration and integration of the logistics subsystems of the construction material manufacturing companies.

The above finding contrasts with systems collaboration and integration indicators, as explained in Chapter 2 and Chapter 3. If companies worked together, they would achieve efficient and effective services for customers. This would only result if there was seamless linking processes between firms, with them collaborating at both strategic and operational levels (Flynn, Huo and Zhao, 2010:58; Jaradat *et al.*, 2017:11). In addition, it must be noted that collaboration includes mutual trust and commitment, information sharing, joint ownership of decisions and rewards, forecasting sharing and working across boundaries to build value-adding offerings which are key system collaboration and integration indicators. This was confirmed by (Huo, 2010:596; Jayaram and Tan, 2010:262).

The ability for firms to work closely with and trust each other will be the main factor as to how quickly collaboration does take place (Gwynne, 2014:20). In logistical systems, synergistic performance is targeted customer service at the lowest possible total cost. Although logical and indisputable in concept, effective application of systems integration is operationally difficult (Bowersox *et al.,* 2013:292).

6.4 Analyses of Efficiency in Manufacturer Warehouse Processes

Objective 3: To analyse the efficiency of warehouse processes applied to construction material manufacturers in North-Central Nigeria.

The effective and efficient management of any warehouse requires that all its basic components function effectively and efficiently as individual systems and together as

an integrated system (Vishnu, 2016:160). This section demonstrates the inter-relationship between labour, technology, equipment and warehouse layout.

6.4.1 Manufacturer Warehouse Structure

The study investigated the type of network structure used in the manufacturers' warehouses. The findings revealed that all the manufacturers adopted break-bulk structures in their warehouses. This means that consolidated shipment of material was done in Full Truck Load (FTL) from the manufacturer warehouse to the distribution centres/warehouses and retailer stores. The material was then further broken down into smaller units and transported to the end-users. It can be inferred that the break-bulk structure of the warehouse allowed for such consolidation in shipment. Therefore, economies of transport were achieved for the long-distance haulage.

This result was in line with breakbulk transportation benefits as explained by Ballou, 1999:144; Apte and Viswanathan, 2000:293 and Bowersox, *et al*., 2013:226) in Chapter 3 of this thesis. It is significant that transportation economies can be obtained by using a breakbulk structure warehouse.

6.4.2 Floor Sizes of Manufacturer Warehouses

The study revealed that two-thirds of the manufacturer warehouse floor sizes were between 501- 3000 square metres. This finding is in contrast with the submission by Hoover's INC Company (2014:2), which claimed that to fulfil the complex distribution functions for customers, new warehouses should be made bigger; 92,903.04 square metres is now a common size. The inference is that the size of a warehouse determines its stockholding capacity, and would also affect the transport arrangements made from it (Michael, 2015:16). It can be deduced that manufacturer warehouses were medium in size (between 501-3000 square metres), which limits their capacity for large stockholding.

In addition, the cement companies operated zero-inventory (they had no warehousing system). A zero inventory in cement companies has implication to cover supply during stoppage in production. Many manufacturing companies continue to shut down their operations for vacations, machine maintenance and stock counts. As a result, wholesalers and retailers need to build up their stock to ensure availability for their

customers prior to the shutdown period. But, this does not always happen, therefore creating a shortage of stock (Gwynne, 2014:223). It can be inferred that many companies did not have warehouses that were large enough for optimal benefit to the customer.

6.4.3 Demand and Supply (Weekly)

The study sought to find out how much material was supplied by the companies to meet up with customer weekly demand. The result revealed that 77% of the total quantity of material demanded was supplied by the companies. This confirmed that the material supply was sub-optimal. This was in line with the findings of Ugochukwu, Ogbuagu and Okechukwu (2014:874) that the potential aggregate demand for cement was more than the supply available in Nigeria. Demand was mostly met from inventory. There is clearly a need to provide a safety stock level for protection against demand variability or uncertain demand (Cronje, 2016:240). However, the implication of a sub-optimal supply of construction material is that market mediation costs are related to a balanced supply and demand status. The sub-optimal supply results in lost sales and unsatisfied customers (Havenga and de Bod, 2016:45).

Manufacturers, wholesalers and retailers need to plan for an adequate inventory to satisfy demand (Anichebe and Agu, 2013:94). However, inventory planning depends on future demand estimates flowing upstream from the supply chain. In the construction industry, efficient inventory planning is hampered by the sequence of the supply chain. Until a contract is awarded, the contractors do not know what materials are needed and hence, cannot convey demand (Vidalakis,Tookey and Sommerville, 2011:77).

6.4.4 Packaging of Material for Transportation

Some construction materials did not need any form of packaging (Refer to Figure 5.91). This can be explained by the significant number of deliveries of sand and crushed stones (in bulk form). The other materials that were delivered required some form of packaging, namely bags, cartons and bundles were used. There is a relationship between the type of construction material being transported, and the packaging style required specifically for that same material. In the end, all the above

combined factors affect also the choice of the type of vehicle to be used to transport the material.

The packaging of cement, ceramic tiles and hollow sandcrete blocks was not palletised or unitised for transportation. This is contrary to the Link 51 project management (2010:4) submission that companies should use industry-standard pallets and containers to eliminate double-handling, minimising the risk of product damage and making the best use of space. It should be noted that economies of scale are affected by inventory handling, as it is cheaper to ship in pallets or containers than in individual units (Antoniolli, Jhonathan Ferreira, Argoud and Camargo, 2015:3). The weight and size of packaging can greatly impact the shipping of any material (Niggi, 2017:52). Logistically, the packaging of some material (cement, ceramic tiles and blocks) for transportation was sub-optimal.

6.4.5 Order Picking Method Used in Warehouses

This is the area in which advances in technology have transformed the picking operation and improved accuracy and productivity significantly. Hence, this study sought to understand the type and level of technology/automation that was adopted in the warehouses to improve their efficiency.

The study established that most of the companies used the paper picking method. This was confirmed by the findings of Gunasekaran, Marri and Menci (1999: 329); Ramaa, Subramanya and Rangaswamy (2012:19); Chen, Cheng and Huang (2013:3392), as discussed in Chapter 3 of this study. Details of the pick are entered manually onto the system. Error is possible if the writing is illegible or if there is confusion over the way it is written. This all adds time to the operation (Gwynne, 2014:138). This also leads to inefficiency in the warehouse - poor management and slow manual operations lead to low throughput, long lead time and high labour costs. A reduction in paper work and operation time will lead to a reduction in human mistakes, and an increase in the efficiency of the logistics system through speed, accuracy and dependability (Kapoor, Zhou, and Piramuthu, 2009: 529; Eckhardt and Rantala, 2012: 614). The inference is that the order picking processes adopted by companies are sub-optimal and inefficient.

The study recommends technologies such as, voice technology, picking by light system and WMS to improve order picking processes. Picker to good strategies remain the most utilised method within todays warehouse operations', however good–to-pickers methods are gaining ground as automation becomes more supplicated and affordable. It has potential to reduce construction cost, reduce project delay, improve productivity, reduce labour working hours and promote time saving. The Value –added services include, reliability, cost- effectiveness, flexibility, lead time. There are many picking strategies that can be utilised within a warehouse operation. Each one will depend on the nature of the products, the velocity of throughput and the company budget.

6.4.6 Material Handling Equipment Used in Warehouses

The study results revealed that a few companies did use material handling equipment such as shovel loaders, mini automated loaders, high level order picking cranes and fork lift trucks. Most of the manufacturing companies did not use any handling equipment in their warehouses. The implication is that multiple handling of material causes low productivity in the warehouse.

The findings contradict the Baker and Perotti (2008:64) results on a survey of the type of equipment used in UK warehouses. They found that most companies use a combination of equipment to handle different types of products and order profiles. Furthermore, the importance of the use of material handling equipment cannot be over-emphasised. Rajesh and Subbaiah (2015:117) found that the use of Material Handling Equipment (MHE) led to reducing worker efforts by decreasing forces in lifting, handling, pushing and pulling materials. Automation can increase productivity, improve product and service quality, and boost a worker's morale. It also decreases damage to materials, possible through human error or negligence, and reduces fatigue and injury when the environment is insecure or inaccessible (Kay, 2012:20). Therefore, it can be deduced that automation of the material handling processes in warehouses is minimal.

Therefore, the study proposes adoption of mechanisation/automation of warehouses. This can be achieved through incentives such as changes in legislation, contracts to

facilitate reverse logistics, tax relief on importation of plant and equipment by enterprises and others.

6.4.7 Storage Equipment Used in Warehouses

This study's results established that most of the manufacturing companies used floor/block storage methods in their warehouses. This finding was supported by Baker and Perotti (2008:64), whose study of the modern warehouses of a group of companies revealed that the most popular form of storage was floor storage and standard wide aisle racking. The goods are packed in unit loads, and stacked on the floor to their maximum height, which is governed by the weight in this sample of warehouse operators. The warehouse height of 15m creates double volume to allow for optimal aisle width for fork lift truck and cube method space utilisation (Gwynne, 2014:219; Vishnu, 2016:166).

Gwynne (2014:254) submitted that most of the mechanical handling and storage equipment manufacturers do have sophisticated systems, including simulation software that can assist companies with planning as to what type of racking and MHE will efficiently suit their operations. The question then is why the companies included in this study have not yet taken advantage of such systems. The study revealed that the use of storage equipment was minimal.

6.5 Evaluating the Efficiency of the Transportation Process on Material Delivery

Research Objective 4: To evaluate the efficiency of transportation being used for the delivery of construction material from the manufacturer plants to distribution warehouses, retailer stores and construction sites.

Knowledge of transportation economies and pricing is essential for effective logistics management. The primary drivers of transportation costs are distance, volume, handling, cost level, economies of vehicle size and economies of distance. This section presents the results related to transportation process efficiency for materials delivery.

6.5.1 Mode of Transportation

All the construction materials manufacturing companies used the road as their main mode of transportation for the delivery of material to customers. This finding corroborates earlier studies of distribution of cement in Nigeria. Adebumiti *et al.* (2014:242) and Abimbola, Charles and Akinlabi (2014:124) confirmed this, as discussed in Chapter 2 of this thesis. However, Adesanya (1998:181) observed that the usage of roads is mainly ascribed to the natural advantage allowed by the presence of the huge land mass that is Nigeria. Railways are not given adequate consideration.

Steyn and Bean (2011:30) established that a rise in vehicle repair and maintenance costs was inevitable due to worsening road conditions. This could lead to an escalation of about 10% in the total logistics costs of a firm. Road transportation in Nigeria is characterised by many delays resulting from heavy traffic, accidents and break downs on the way. An effective and efficient transportation system is needed for business to function in any industrialised society (Abimbola, Charles and Akinlabi 2014:124). Thus, it can be inferred that roads as the only mode of transport is sub-optimal for delivery of construction material.

Therefore, the study suggests that the Nigerian government should collaborate with the private sector through Public Private Partnership to construct and maintain these roads as there are some stakeholders that are committed to developing a less troublesome road network.

6.5.2 Vehicle Ownership

This study revealed that most of the companies used third party transport providers for the delivery of material. This finding agrees with Flinders (2015:184) result that the use of third party transport providers has grown dramatically over recent decades. Customers find this acceptable. Moreover, there are benefits to using the third-party transport providers as against in-house transport operations. This was explained by Seyed-Alagheband (2011:76) and Deepen (2007:28) in Chapter 2. This included meeting customer service expectations in a more cost-effective manner than could be achieved by manufacturing companies performing the job themselves.

The study also established that there was no synergy between the manufacturers and third-party transport providers. All the arrangements for deliveries were done between independent transporters and customers, either directly or through agents. This would always be a once off arrangement. This supports the assertion by Seyed-Alagheband, (2011:76) that it was difficult to find dependable and cost-effective co-operation between the shipper and the 3PL provider. If a manufacturer outsourced a logistics operation, it risked losing experience in logistics. Manufacturers outsourcing their logistics processes were frequently worried about the security of company information because they would have to share secret records (Van Damme and Van Amstel, 1999:85). Therefore, it can be deduced that the use of third-party transport providers is sub-optimal.

There is a need for the manufacturers, transport operators and other stakeholders to work closely to reduce vehicles moving empty. A seminar, training or workshop to show benefits could be conducted in conjunction with authorities or organisations but this will depend on the organisation and commitment of stakeholders to the proposal.

6.5.3 Condition of Vehicles

The results revealed that most of the vehicles used for delivery of material were well maintained. This is significant in terms of any recommendations to be made, since new and well maintained (good condition) vehicles represent a considerable investment for owners.

Few vehicles were in poor condition. This is a significant finding as old vehicles are not only uneconomical to keep, but they tend to smoke and produce pollutants (Shakantu, 2005:242). They break down frequently and contribute to the disruption of the delivery schedule, which might lead to an increase in transit time, and overall lead time. However, it can be inferred that most of the vehicles utilised were new and in good condition.

6.5.4 Vehicle Total Capacity

Most vehicles used by companies were of 30-ton capacity. They were dedicated, single use vehicles for delivering material from the manufacturer plant to DC/WHs, Retailer stores and Sites. In most cases, they were the vehicles shipping material such

as cement, reinforcement bars, ceramic tiles and crushed stones for long distances. This was supported by Shakantu and Emuze (2012:666) that the method most commonly used to deliver material to construction sites was that of dedicated, single use vehicles. This referred to trucks being used from the manufacturer to points of consumption on sites. Big deliveries were better transported over long distances, if at all possible (Bowersox *et al.,* 2013: 295). Most importantly, the economies of vehicle size were achieved. As the carrying capacity of vehicles increased, vehicle-specific costs also increased, but less than proportionally to an increase in vehicle size (Pienaar, 2016c:388).

In terms of smaller tonnage, 10-ton vehicles made the largest number of deliveries. They were followed by the 5-ton, 15-ton, 20-ton, and 25-ton vehicles. These were mostly used for short distance delivery of materials such as sand and blocks. Vehicles of different types and capacities were used for material delivery. Blocks were an exception, as they were sometimes in Less Truck Load (LTL) deliveries to sites. It could be inferred that most vehicles of 30-ton capacity were used for long distance deliveries. The 10 tonnage vehicles were used for short distances.

6.5.5 Tonnage Loading - State of Vehicles on Arrival and on Departure

The analysis revealed that the state of all vehicles on arrival at the manufacturer plant/warehouses were empty. This signifies vehicles running empty in one direction. But almost all vehicles departed in FTL from the manufacturer plant to various DC/WHs, Retailer stores and construction sites.

The findings support the submission by Shakantu (2005:270), that vehicles running empty in one direction operate at 50% loading efficiency. Those vehicles running empty on both trips are really operating at 0% loading efficiency.

In logistical terms, the empty runs are an unsustainable use of vehicles. The empty drive still uses fuel and contributes to the wear and tear of the vehicles concerned. This was discussed by McKinnon and Ge (2006: 391) and the United State Census Bureau Service (2010:14) in Chapter 2 of this thesis.

However, transport providers need to work in partnership with other transport providers in similar or dissimilar companies. They could share vehicle size or create round trips and continuous moves, thereby reducing the empty running of vehicles (Belson, 2010:24; Ruamsook and Thomichick, 2012:137). This recommendation is additionally corroborated by the findings of Shakantu, Muya, Tookey and Bowen, (2008:434), who established that the use of reverse logistics strategies can result in a 42% saving in empty runs with a significant effect on operating costs. It can be deduced that the loading state of a vehicle on arrival and departure were sub-optimal. The loading system of vehicles was inefficient.

6.5.6 Loading and Offloading Equipment

The study revealed that two-thirds of the manufacturer plant/warehouses used equipment such as automatic loaders for loading cement, high level cranes for loading reinforcement bars, shovel loaders for loading crushed stones /sand, and forklift trucks for loading ceramic tiles. The remaining companies used manual labour in the loading of ceramic tiles (semi-mechanised), blocks, crushed stones and sand.

The results revealed that offloading was done manually at the DC/WH, Retailer stores and Sites. These findings contradict Pienaar's (2016c:381) assertions that to reap the optimum rewards of specialisation, handling equipment at terminals should be provided for rapid loading and offloading of freight to maximise the number of full vehicle load kilometre per unit of time. More so, it also contradicted the view that block manufacturers normally use self-loading vehicles with cranes mounted on the edge or on a removable mounting (Rushton, Oxley and Croucher, 2001:370; Vidalakis and Sommerville, 2013: 478). This truck equipment allows for extra grades of movement for handling unit loads (Hannan, 2011:36).

It can now be deduced that the use of loading equipment at the manufacturer warehouses was minimal, while there was no offloading equipment at the DC/WHs, Retailer Stores and Sites. Hence, loading processes at the manufacturer plant/warehouses, and offloading of vehicle processes at the DC/WHs, Retailer stores and Sites were inefficient.

6.5.7 Number of Vehicles Loading at a Time

The study found that most of the manufacturer loading bays had the capacity to load four (4) vehicles at a time. There was no traffic congestion observed at the manufacturing companies' dispatch bays. This contradicts the submission that vehicles waste time due to congestion at the docks of plants, or at the DC/WHs and Retailer stores (Eskigun *et al.*, 2005:181; Gwynne, 2014:73). On the other hand, the waiting time could be due to administrative issues or inefficiencies in the system that are unrelated to the volume of Vehicle passing through these locations (Eskigun *et al.*, 2005:181; Gwynne, 2014:73). On this premise, it can be inferred that vehicle waiting time at the terminals was not related to the congestion at the loading bay. This long waiting time may be as a result of other adminstrative issues or inefficiencies in the system.

6.5.8 Loading and Offloading Periods

Most of the company loading took place between 08h00 – 18h00. This was when vehicles were loaded and offloaded at the terminals. Similarly, most offloading times at the DC/WHs, Retailer stores and Sites were between 08h00-18h00. This means that vehicles are used only during operational hours, which leads to the longer dwell time of fourteen hours per day in each terminal, or both.

These results are in line with findings by Grupp *et al.* (2004:237) and Rahman *et a*l. (2013:171). They confirmed that long-haul trucks were idle for between six and sixteen hours per day. The sum of the load make-up time or the time losses constituted the total waiting time or DT of vehicles at the terminal. This was before they were sent off to their next location (Eskigun *et al.*, 2005:181). This is also supported by Andrejić, Bojović and Kilibarda (2013:3926) that inefficiency is measured in terms of the amount of time spent waiting on-site.

However, the findings are contrary to the fact that transport efficiency is achieved by full loads and utilising the transport for as long as possible each day (Vogt, 2016b:342). In addition, flexibility of loading and offloading times can significantly improve productivity and increase efficiency of vehicles. Therefore, it can be deduced that underutilisation of vehicles during operational hours is due to the longer dwell time of

fourteen hours per day in each terminal, or both. This was due to restrictions and the inflexibility of loading and offloading periods.

6.5.9 Load and Offloading Time

The study sought to confirm the average time taken per ton for loading and offloading each material. The results revealed much disparity in the average time taken per ton for loading and offloading each material. It took much lesser time per ton to load at the manufacturer plants where the loading was done mechanically. It took more time per ton to offload at the DC/WHs, Retailer stores and Sites where all loading was done manually. These processes combined used fewer machines, but more manual labour that involved multiple handling.

These findings contradict the assertion by Pienaar (2016c:380) that economies of density was enhanced by using high capacity technology to carry and handle large bulk loads, minimising loading and offloading times. However, the offloading process can be more efficient. It can be improved by 61% if it improves its information systems (Andrejić and Kilibarda, 2016:143).Therefore, the efficiency of loading and offloading processes time per ton is sub-optimal.

6.5.10 Loading and Offloading Costs

The study also revealed the average cost per ton for loading and offloading of individual materials. The results reveal much disparity in average cost per ton for loading and offloading individual materials. It costs less per ton to load than to offload in companies where most of the loading was done mechanically, as against all offloading being done manually at the DC/WHs, Retailer stores and Sites.

The findings corroborate Michaels' (2015:16) submission that each point of stockholding comprises handling of material. The more multiple handling of material, the more the overall logistics expense. Each time a material handling person or a machine operator touches the material, the cost of their touch time goes up. The implication is that the touch time costs are non-value-added costs that will never be recovered when an invoice is calculated for the load (Niggi, 2017:52) Thus, for construction material, the efficiency of loading and offloading cost per ton are sub-optimal when evaluated logistically.

6.5.11 Vehicle Utilisation Efficiency

The average vehicle shipping efficiency (VSE) calculated was 97.22%. It can be deduced that these vehicles with high average VSE are more likely to be used for dispatch. This finding was supported by Vogt's (2016b:342) results of 95% vehicle load efficiency for a sample of eight UK companies' outbound stage deliveries.

The Vehicle Loading Efficiency (VLE) using the formula given in Section 5.3.4.11 was computed. This comprised both forward and reverse vehicle movements. It established an average VLE for the construction material deliveries as 9.722%. This finding was lower than Vidalakis and Sommerville's (2013:473) study, where the results for the average VSE calculated for the BM was 24.1%, and for the MS was 39.4%. This was due mainly to the frequency of empty runs occurring during backhauling, which was confirmed by the very low collections/deliveries ratio.

The utilisation efficiency average of 50% or less supports the need to improve efficiency through logistics integration (Shakantu, 2005:263). Therefore, with the computed average VLE as 9.722%, it can be deduced that the vehicle utilisation efficiency was sub-optimal. It is thus inefficient and needs to improve through logistics integration.

6.5.12 Vehicle Technology

The study sought to find out the level of utilisation of technology to integrate the transport system with the other sub-systems. The finding revealed that most vehicles used for the delivery of material do not have any transport system software installed in them. A few vehicles owned by the cement companies did have tracker and speed limits installed in them. This was to enable their head office to monitor and track their vehicles. This did not link them to other sub-systems and customers.

Andrejić and Kilibarda (2016:143) found that it was necessary to integrate the transport management system, warehouse management system and other systems. Most importantly, the utilisation of TMS software can provide effective and efficient management of the transportation fleet used in the distribution network (Apte and Viswanathan, 2000:300; Andrejić and Kilibarda, 2016:143). The other benefits of such

software have been discussed under several sub-themes (Stoffel, 2009:18; Wright, 2010:31; Biederman, 2011:78) in Chapter 3: Section 3.6.5.

This study found that there was minimal use of transport management system software in vehicles. It can be thus inferred that the transport management system was sub-optimal and inefficient.

6.6 Technology Adoption in Logistics Processes

Research Objective 5: To determine the level of technology being used in logistics processes by the Nigerian construction material manufacturers.

The adoption of the right technology for different logistics operations or sub-processes is critical for improving the total effectiveness and efficiency of a logistics system. This formed the crux of Research Objective 5, to determine the level of technology used in logistics processes. This section discusses the results under the sub-headings: AutoID Tools, Communication Technology Tools, Information Technology Tools and e-Business.

6.6.1 Automatic Identification Technology (Auto ID)

The researcher sought to find out the type and level of application of the AutoID tools within Management-CMLS. The result revealed that all the manufacturing companies did not use any of AutoID tools in their logistics operations. This finding contradicts a study by Biju and Faisalu (2013:147), which established that the majority of companies currently used bar coding. They opined that most of the AutoID tools are highly necessary and should be implemented. Bar codes increase productivity in three ways: speed, accuracy and reliability (Sople, 2010:77; Bhandari, 2013:21).

However, the Aberdeen Group (2009:15) reported that 70% of Best-in-Class companies are more likely than all other companies to receive goods without using paper documents. All have migrated to the use of barcodes, RFID or voice technology. In the light of this knowledge, it can be deduced that the logistics process of identification and recording of data is sub-optimal.

6.6.2 Adoption of Communication Technology Tools

In addition to determining the AutoID tools, this study also assessed the type and level of communication tools adopted in the logistics process. The finding was that most of the manufacturing companies did not utilise many of the communication technology tools in their logistics operations. A few companies used GPS, GIS and Web-based tools for tracking and monitoring their vehicles. They also used these for vertical communication between Headquarters, drivers and distribution centres, but not for horizontal communication with other logistics partners.

Consequently, the low utilisation affected the companies from realising the full benefits of communication tools as discussed in Chapter 3: Section 3.9.2. For instance, the efficiency of a WMS technique is higher than when the operations are done by hand (Ramaa, Subramanya and Rangaswamy, 2012:20). If EDI links are in place between suppliers, manufacturers, retailers, customers and the banks, then a totally paperless supply chain would be possible. Inventory activities can be automated in order to make it easy to locate stocks in a warehouse (Ndonye, 2014:7).

It can be inferred that the current method of communication utilised in the logistics processes by the construction material manufacturers as sub-optimal, thus ineffective and inefficient.

6.6.3 Adoption of Information Technology Tools

The study further sought to find out which information technology tools were being used in the Management-CMLS. The finding was that most of the companies did not use any information technology tools, except for the cement companies that utilised ERP in their logistics operations.

This finding was supported by Wilson *et al. (*2015:18) that the level of application of ERP, JIT, RFID and VMI are very low among suppliers. However, this contradicts the assertion that the higher the level of information technology used in a firm, the more effective and efficient that firm is (Biju, and Faisalu, 2013:143). In addition, information can be viewed as the life blood of a logistics system. It acts as the glue in logistics roles, holding the network together and managing all components of logistics

(Asadi, 2011:221). It can be now deduced that the level of information technology utilised for logistics operations was sub-optimal.

6.6.4 E-Business Adoption

In terms of e-business adoption, this study found that most of the manufacturing companies had not adopted e-business applications. In addition, the study revealed that only a few of the companies use the internet, web-based tools and e-banking in logistics operations. However, these are used for payments by customers and for receiving credit alerts by the companies. This does not provide for information sharing or collaboration and integration with the other stakeholders in the logistics system.

Cronje (2016:250) asserted that Collaborative Planning, Forecasting and Replenishment (CPFR) was a process initiated by the Fast-Moving Consumer Goods (FMCG) industry to coordinate the individual forecasts of different participants in the supply chain. Instead of retailers, distributors, manufacturers and transport providers each producing their own forecast, they could share, discuss, harmonise and rationalise individual plans to create a combined plan. It is a business practice that combines intelligence of multiple trading partners in the planning of how to fulfil customer demand (Sari, 2008:498). The internet provides an efficient way to exchange information with customers (Giménez and Lourenço 2008:308). Having a computerised, combined network that interfaces related internal departments, external partners and coordinates the information between them would significantly influence correct and reliable responses to customers. This would ensure customer satisfaction (Fallah, 2011:203).

In view of the very low adoption of e-business applications being used by the manufacturing companies, it can be inferred that the level of e-business usage in logistics operations was minimal.

6.7 Assessing Efficiency of Warehouse Processes from a Customer Satisfaction Perspective

Objective 6: To evaluate the level of customer satisfaction for the delivery of construction material from the manufacturer plants to distribution warehouses, retailer stores and construction sites

Some investigations and interpretations are based on the results of customer input on a company's performance. This enables management to understand the areas of underperformance and plan for remedial action (Fallah, 2011:218). This section discusses the results relating to evaluating the level of customer satisfaction on the delivery of construction material by the manufacturing companies.

6.7.1 Perfect Order Completion Indicators

The study sought to determine the level of customer satisfaction using perfect order measures. The study revealed that 67% of the customers received their orders on time. The finding supports the result of the on-time shipment study by Manrodt, Vitasek and Tillma (2014:12). They found that 85% of customers received their orders on time.

However, if the result is compared with the WERC (2010:142) Customer Quintile Benchmark Metrics (Refer Table 5.6), the Best-in-Class for On-Time is 99.8%, while any value less than 96% is a *Major Opportunity for Improvement*. Since the research value of On-Time is 67%, which is far less than the 96% Quintile Bench mark, it can be deduced that on time delivery of materials by the manufacturing companies was sub-optimal.

The other major findings were that the majority (93%) of the materials were received free of any damage. While orders were shipped in full, order fill rate and order accuracy were all rated at 100% each. However, if the result (93%) of materials received damage free is compared to the customer Quintile Benchmark Metrics (Refer Table 5.6), the Best-in-Class is 99.5%. while any value less than 95% is a *Major Opportunity for Improvement*. Therefore, it can also, be inferred that damage free deliveries are sub-optimal.

In terms of the Perfect Order Completion Index, which is a summary of on-time, damage free, orders shipped in full, order fill rate and order accuracy, this study established that 61.86% orders met the Perfect Order Completion Index. When the result is compared with the WERC (2010:142) Customer Quintile Benchmark Metrics (Refer Table 5.6), the Best-in-Class for Perfect Order Completion Index is 99.3% of orders. Any value less than 85% is a *Major Opportunity for Improvement*. This research study exposed a Perfect Order Completion Index value of 61.86%, far less than 85%. It can thus be deduced that Perfect Order Completion processes for delivery of materials by the manufacturing companies was sub-optimal. This indicates a *Major Opportunity for Improvement.*

6.7.2 Internal Order Cycle Time

The study also sought to find out how long it takes the manufacturing companies to process an order internally. The analysis revealed that the majority of the company's internal order cycle time was greater than 27.4 hours.

The decision rule as indicated in the Customer Quintile Benchmark Metrics (Refer Table 5.6) is that any value of internal order cycle time *greater than 27.4 hours means a Major Opportunity for Improvement.* Most of the company's internal order cycle times were greater than 27.4 hours. It can thus be inferred that the internal order cycle time for processing construction material by the manufacturing companies was sub-optimal. This means it provides a *Major Opportunity for Improvement*.

6.7.3 Total Order Cycle Time

Having established the internal order cycle time, this research study further investigated the total order cycle time. This is the measure of elapsed time from the order receipt until the customer receives the product. The finding revealed that most of the companies had a total order cycle time that was greater than 72.4 hours. The mean was 102 hours.

The decision rule as presented in the Customer Quintile Benchmark Metrics (Refer Table 5.6) is that *any value of total order cycle time greater than 72.4 hours means Major Opportunity for Improvement.* Therefore, since most of the companies had total

order cycle times that were greater than 72.4 hours, it can be concluded that they were sub-optimal.

6.8 Framework for Effective *and* Efficient Construction Materials Logistics Management

Research Objective 7: To develop a framework for efficient and effective construction material logistics management.

The Management of Construction Material Logistics Systems plays a significant role in meeting the goals of cost, quality and time to completion of a construction project. Fundamentally, it is accepted that any inefficiency in the delivery of construction materials leads to a rise in material costs and, thus, a rise in construction costs (Vidalakis and Sommerville, 2013:479). However, the current materials logistics system did not meet the delivery goals of cost, quality and time of a construction project. Based on the investigations and interpretations conducted on the empirical findings, some areas with *Major Opportunity for Improvement* in construction material logistics management were identified. A plan for remedial action was thus proposed through a framework.

The framework was developed, firstly from the articulated literature on the fundamental concepts of systems, effectiveness (maximising customer satisfaction) and efficiency (minimising the use of resources) of construction materials logistics management. Secondly, from an understanding of current condition of construction materials manufacturers logistics management utilised by the firms surveyed in Nigeria.

The framework is presented on Figure 6.1, and further discussed under the sub-themes of: Efficiency in the logistics system; Efficiency in warehouse processes; Efficiency in transportation, and Effective customer satisfaction that follows in sections 6.8.1 to 6.8.4. Figure 6.1 illustrates a typical framework for effective and efficient Management-CMLS. It presents the flow directions of material and information. The black double arrow head symbols signify delivery and return of material from the manufacturing industry to customers. The red double arrow lines represent the flow of information from the manufacturing industry to the logistics partners (customers) and vice versa. The framework aims at identifying and improving the effectiveness and

efficiency of processing in the manufacturers warehouse and within the outbound logistics channels. The typical outbound logistics channels indicated in Figure 6.1 include:

- Manufacturing firms - Distribution centres /Warehouses- Construction Sites.
- Manufacturing firms- Distribution centre/Warehouses- Retailer Store- Construction Sites.
- Manufacturing firms - Retailer Stores - Construction Site.
- Manufacturing firms - Construction Site.

Figure 6.1 is presented, and the larger expanded and readable version is on Appendix B page 317.

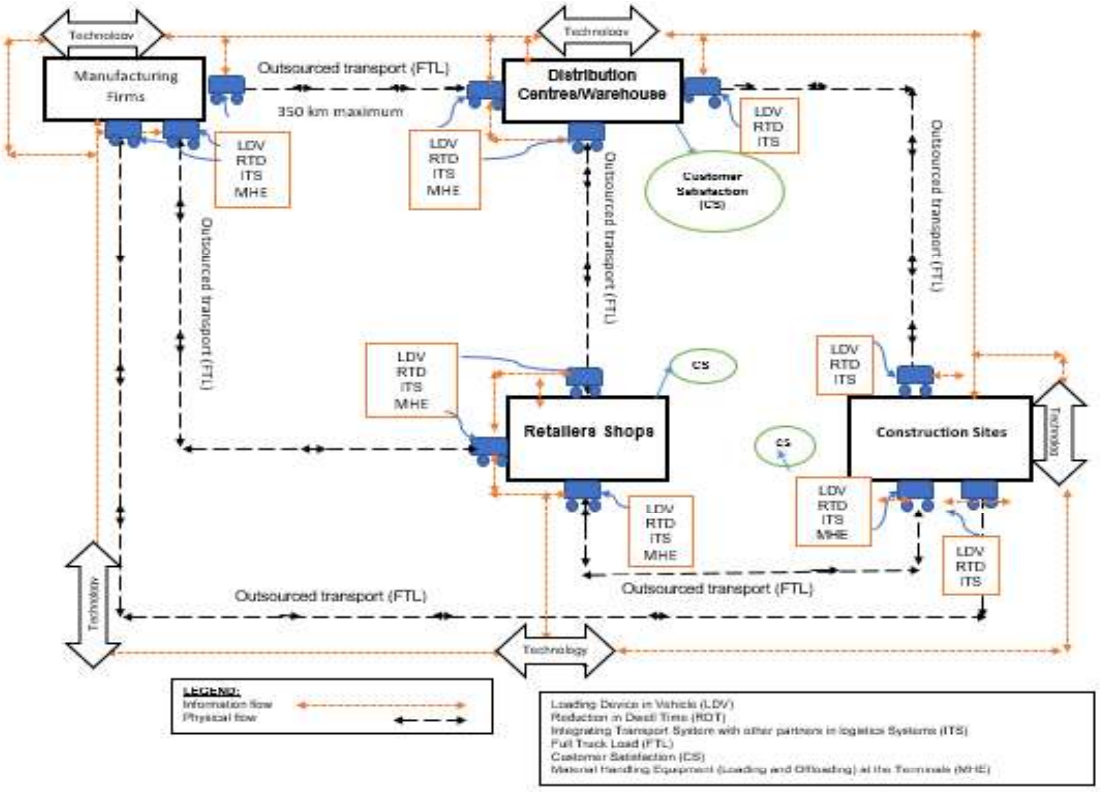

Figure 6.1: Framework for Effective and Efficient Construction Material Logistics Management
Source: Author's Design (2019)

6.8.1 Efficiency in the Logistics System

The major parties in the logistics system are manufacturers of construction material, traders of these materials and contractors. In this logistics system, IT is directed

towards the external integration of computerised systems of different firms and more efficient communication between the parties involved. These technologies such as WMS, EDI, RFID and barcode, have changed the inventory strategy by improving communication between retail branches, central warehouses and manufacturers. It has stimulated the centralisation of inventories and lowered inventory levels. At the same time, the use of IT has made it easier to plan the delivery of smaller consignments and to improve the planning of transport. The implementation of the framework involves change in the whole structure of the logistics system. Therefore, there is need to follow certain steps, which includes:

- Optimising the use of multiple alternative or combined logistics channels.
- Optimising direct-to-end-user sales strategy and encourage online sales.
- Adopt strategies such as mass customisation, outbound logistics partnership and quick consumer response.
- Creating relationships, mutual trust and commitment with other logistics partners.
- Optimising collaboration and integration of the logistics systems.
- Adopting information and communication technology for receiving, recording, processing and sharing information with logistics partners, thereby operating as a system. This will improve productivity and efficiency and create real-time data updating.

6.8.2 Efficiency in Warehouse Processes

Efficiency in warehouse processes includes, management plans, controls, and optimising the material flows and the use of the resources in a warehouse in an everyday context, with the objective of delivering goods in accordance with customer demand while minimising operational costs (that is eliminating unnecessary work and unnecessary movement of people and equipment).

Automating the basic warehousing processes is required to achieve an increase in throughput rates or inventory turns and cost effectiveness. It is necessary to allocate warehouse resources efficiently and effectively to enhance the productivity and reduce the operation costs of the warehouse. One vital area determining the efficiency of a warehouse is the determination of the proper storage locations for potentially

thousands of products in a warehouse. Therefore, there is need to follow certain steps, which include:

- **Optimising packaging for transportation:** There is a need for use of standard pallets or containers for the transportation of material (cement, ceramic tiles and blocks) to create a unit load. This will assist to eliminate multiple handling during loading and offloading, minimise the risk of material damage and make the best use of space in the vehicle. It can also reduce loading and offloading time and cost and improve productivity. The pallet or container should be reusable (recycle) to enhance sustainability.
- **Optimising Automation/ Mechanisation of warehouse processes:** The warehouse processes of picking, material handling and storage should be automated /mechanised. The use of a combination of or separate equipment to handle different types of materials and order profiles will improve productivity and enhance efficiency. The study suggests automation of manual process and use of equipment such as forklifts, high level cranes, power pallet jack, sortation conveyors and automatic loaders.
- **Optimising AutoID technology in warehouse processes:** Use some of the basic AutoID tools, such as barcode, RFID, voice technology and the pick by light system to reduce duplication of effort, minimise human error and increase productivity. This will improve efficiency by giving real time data updates.
- **Adopting Effective warehouse processes:** Total quality management (TQM), Just in Time (JIT) philosophy and LEAN Administration will eliminate waste. Effective training helps to motivate staff and ought to be a continuous procedure. It affords the operator a sense of development and builds flexibility into the process.
- **Optimising training of staff skills and experience:** Optimise training of operatives across disciplines on the use of modern technology and equipment. Effective supervision and management support an open interchange of ideas, as does regular deliberation with staff peers. Staff need to acquire basic skills of ability to delegate effectively, practise excellent communication, have motivational aptitudes and problem-solving skills, among other strategies.

6.8.3 Efficiency in Transport Processes

Efficient and effective transport helps ensure that customers receive the right goods at the designated place and time in the required condition and quantity, and at an acceptable cost or price. The most pertinent service performance determinants are suitability, accessibility, good security, transit time, reliability and flexibility. In addition to the primary transport service, professional carriers also provide certain complementary terminal and line-haul services that enhance the flexibility of their service. Government also applies various policy instruments to influence the performance of the freight transport industry. These policy instruments are legislation; monetary measures; procurement policy and provision of information to the stakeholders. The transporters must offer intelligent systems in their vehicles and systems. Therefore, there is need to follow certain steps, which include:

- **Intermodal Transport**: Introduce intermodal transport (Railroad) for long distance haulage above 500 kilometres to achieve economies of transport.
- **Optimising the use of third-party transport providers:** All manufacturing companies should have synergy with the independent transport providers, distributors, wholesalers, retailers and end users to improve transport efficiency.
- **Optimising vehicle capacity:** Maximise the use of trucks of bigger capacity (30 tonnes and above) for the long-distance shipment to fulfil a larger number of orders, while performing a lower number of vehicle movement.
- **Minimising Loading and Offloading Time and Cost:** Specialised handling equipment/automation should be provided at the terminals for loading and offloading, which will also increase productivity. This will minimise loading and offloading time and cost. More so, block manufacturers should use self-loading vehicles with cranes mounted on the edge. As the current practice shows, blocks loading, and offloading are done manual.
- **Minimising Loading and Offloading Period:** Minimise the restriction on loading times by the manufacturing companies and offloading times by the customers**.** The flexibility of loading and offloading times (extending the time beyond normal working hours) will significantly reduce dwell time and improve productivity and the potential to increase efficiency of vehicle utilisation.
- **Minimising Frequency of Vehicle Empty Runs:** Minimise frequency of empty runs occurring during the forward journey. This supports the need to improve

efficiency through forward and reverse logistics integration. Transport providers should work in partnership with other transport providers, in similar or dissimilar companies, to share vehicle size or to create round trips and continuous moves. This programme allows participating shippers to increase the fill rate of trucks, reduce empty miles and costs, and make a direct contribution to reducing its carbon footprint.

- **Optimising Transport Management System:** Adopt the use of software for the transport management system to integrate with the warehouse management system, and other systems. This will provide for the effective and efficient management of the transportation fleet used in the outbound logistics system. It will also help in monitoring and tracking of material in transit.

6.8.4 Effective Customer Satisfaction

- **Perfect order completion indicators**
    i. **Optimise on time delivery:** Integrate WMS and wireless computing to manage receiving, put away and pick up. In addition, use GPS and wireless communication to redirect and track /monitor deliveries, reduce drive time and track shipment en-route. Provide advanced shipping notices/ electronic data interchange (EDI) and mobile computers to speed up check-in loading and check-out operations with automated documentation.
    ii. **Optimise accurate invoicing and documentation:** Adopt the use of technology such as scanning barcodes, RFID, EDI, voice picking and mobile printers to identify material and record the items as they are received, labelled and put away to improve accuracy and enhance productivity. These will enhance real time data updates.
    iii. **Minimise damage free delivery:** Adopt the use of mobile computers with integrated images to take pictures to provide documentation that materials were shipped and delivered without any damage. The current practice does not provide a feedback mechanism from the customer.
    iv. **Minimise order cycle time:** Adopt the use of technology such as RFID, WMS.ERP, EDI and LEAN in the order processes to reduce non-value-

added time and improve internal efficiency and effectiveness. This would minimise both internal order cycle time and total order cycle time. This would then improve productivity and reduce lead time.

6.9 Chapter Summary

This chapter summarised and discussed the results of the research study based on the research problem (Section 1.3), research question (Section 1.4) and objectives (Section 1.5). The chapter also discussed the strategies for effective and efficient Management-CMLS for the Nigerian construction materials manufacturers.

Chapter 7 presents a synopsis of the research, conclusions, contribution to the body of knowledge and recommendations.

Chapter 7: Summary, Conclusions and Recommendations

7.1 Introduction

This chapter presents a synopsis of the study. It also presents the conclusions drawn from construction materials logistics management (Management-CMLS) as practised in North-Central Nigeria. The chapter also presents the research study's contribution to knowledge, areas for further research and recommendations.

7.2 Summary of the Research

This thesis contributes to the better understanding of Management-CMLS. It was observed that there was insufficient awareness of the relationship between Construction Supply Chain Management (CSCM) and logistics efficiency. This confirmed that the fundamentals of operational methods and strategies for effective CSCM were not fully recognised or understood by personnel employed in the construction industry (Ying, Tookey and Roberti, 2013:272).

This thesis explored the concept of the logistics system, which has the dual aim of efficiency and effectiveness. Efficiency is the minimisation of total logistics costs, while effectiveness is the maximisation of final customer satisfaction. These two objectives need to be balanced in a tactical way (Elena and Giacomo, 2001:4). Furthermore, there is a need for the holistic collaboration of all stakeholders who participate in the supply chain operation system, one that will find an equilibrium between the two seemingly conflicting objectives of effectiveness and efficiency (Sardana, 2009:40)

More research is required in the field of Management-CMLS to improve the insights of the logistics system and to measure its operational performance, as practised by the manufacturers. The research problem, research questions, and objectives formulated are stated in Chapter 1 and sections 1.3, 1.4 and 1.5.

7.2.1 Theoretical and Conceptual Framework

The literature review provided the desired understanding and theory of systems, effectiveness and efficiency of the supply chain concept. Effectiveness and efficiency are critical to Supply Chain Management (SCM). Any improvement in SCM would have

at its core an efficiently working logistics system. The problem was to understand how effectively and efficiently Management-CMLS was practised and utilised by Nigerian construction materials manufacturers to achieve customer satisfaction, while simultaneously maintaining their profit. Based on the concepts emanating from the theoretical aspects of logistics management, which are central to this study, a conceptual framework was created to evaluate the operational performance of Nigerian construction materials manufacturers, with specific focus on Management-CMLS.

7.2.2 Research Methodology and Techniques

The appraisal of the problems identified in Chapter One pointed to the quantitative approach being the most suitable method for the study. The problem being addressed by the research questions was an objective problem, one in need of observation and measurement. Therefore, the research paradigm selected was positivist, rather than interpretivist. In other words, the output required a representational view of generic construction logistics (Shakantu,2005:170). As such, the quantitative research method was deemed to be able to generate data that was objective, quantitative and fully descriptive of the logistics system employed. The purposive sampling technique was adopted for the selection of the cases that especially informed the subjects of the observation conducted during the study. These subjects had to be representative of the wider phenomenon being studied.

The research instrument had to be able to measure the required dynamics and provide data for the establishment of effective and efficient logistics management. The instrument had to be able to measure the level of technology and automation adopted in warehouse processes, vehicle movement relating to the delivery of construction material from the manufacturers' warehouses to the distribution centres, warehouses, retailer stores and construction sites. Furthermore, it had to capture customer metrics, such as perfect order indicators and order cycle time. To achieve all this, an observation protocol in the form of a template containing the above parameters was created. This was used to record data during the field study.

7.2.3 Summary of Major Findings

The summary of findings relating to the study was based on the Research Questions and Research Objectives.

Research Objective 1: **To identify and examine the current logistics channels utilised by the Nigerian construction material** manufacturers.

- **Logistics Channels**
  The study identified six different logistics channels. However, all the construction material manufacturing companies used multiple or combined logistics channels for their logistics operations.

- **Location and Number of DC/WH and Retailer Stores**
  Half the Distribution Centres and Warehouses (DC/WH), Retailer Stores and Sites were in Abuja, which has a large volume of construction work being done there.

- **Network structures used in DC/WH and Retailer Stores**
  Most of the distribution centres, warehouses and Retailer Stores were of mixed structure, thereby improving product assortment and achieving transportation economies.

- **Size of DC/WH and Retailer Stores**
  All the distribution centres, warehouses and Retailer stores were small, less than 500m². They had limited capacity for large stockholding.

- **Distances between Manufacturer plants and DC/WH, Retailer Stores and Sites**
  Most of distances measured from individual manufacturer plants to distribution centres, warehouses, retailer shops and sites were between 0–350 kilometres for cement, reinforcement bars, ceramic tiles and granite. This was within the recommended distance for achieving road transport economies.

Most distances measured from the manufacturers of blocks and sand sources to the construction sites was between 0-50 kilometres.

- **Distance travelled and transportation costs**
- Most of the individual material average transport costs, per average distance, was above ₦500/km**.**
- Half of the individual material average transport costs, per average ton, were above ₦5000/ ton.
- It was established that the average transportation cost, per average distance, decreased as the distance increased in kilometres.

The established average transportation cost per average ton and average transportation cost per average distance driven can be used for construction material transportation management. In addition, knowledge and understanding of the manufacturers out bound logistics channels can be used at the start of a project to achieve effective planning and delivery of the entire project.

To address research (Sub-question 1) logistics channels were identified through comprehensive literature. The outcome of the literature was validated in the field survey of the Nigerian construction materials manufacturers to determine the logistics channels utilised. Data were collected and analysed for the logistics channels variables in Sections 5.3.1.1 to 5.3.1.5 pages 167-174. In the empirical findings in Figures 5.75-5.81 it is evident that the logistics channels utilised by Nigerian construction materials manufacturers were identified and examined. It can be concluded that the research (Sub-question 1) is thus answered.

The findings in Research Objective 1 above answered Research Sub-question 1: What logistics channels do Nigerian construction materials manufacturers use?

Research Objective 2: **To identify the current logistics systems utilised in Nigerian construction material manufacturing industries.**

- **Logistics System Collaboration and Integration**
  Most of the identified logistics sub-systems were utilised by the construction material manufacturing companies.
  There was minimal collaboration and integration of the logistics sub-systems of the construction material manufacturing companies, and between the other logistics partners.

In this study, through literature review the logistics subsystems, and collaboration and integration indicators were identified. These were verified through field study of the Nigerian construction materials manufacturers to determine their utilisation by the firms. The results in figures 5.84 and 5.85 on pages 175 and 176 indicate the current logistics subsystems utilised, and collaboration and integration of the logistics subsystems was minimal. Therefore, the research (Sub-question 2) is answered.

The findings in Research Objective 2 above answered Research Sub-question 2: What logistics systems do Nigerian construction materials manufacturers use?

Research Objective 3: To analyse the efficiency of warehouse processes applied to construction material manufacturers in North Central Nigeria.

- **Network Structure of Manufacturer Warehouses**
  All the construction material manufacturer warehouses were break-bulk structure. They provided full truck load consolidation in long distance shipment and were then broken down into smaller units at the DC/WH and retailer stores, before being transported in smaller truck loads to individual end-users.

- **Floor Size of Manufacturer Warehouses**
  Most construction material manufacturing company warehouse floor sizes were between 5001-3000m$^{2.}$ They were also about 15m in height, giving room for use of equipment and the cube method of space utilisation.

The cement manufacturing companies did not operate warehouses (this meant a zero-inventory). The implication was that there was no safety stock for protection against demand variability or uncertain demand.

- **Weekly Demand and Supply at Manufacturer Warehouses**
  The relationship between weekly material demand and supply established that the demand for material was more than the supply (supply was sub-optimal). This resulted in either lost sales or unsatisfied customers.

- **Methods of Packaging of Material at the Warehouses**
  Logistically the packaging of some materials (cement, ceramic tiles and blocks) for transportation, was sub-optimal. They did not use standard pallets to create unit loads and reduce multiple handling at the terminals. Packaging for transportation was inefficient.

- **Order Picking Methods Used in the Warehouses**
  Most of the companies used paper picking methods, thus the process was sub-optimal and inefficient.

- **Material Handling Equipment in the Warehouses**
  Only half of the manufacturing companies used material handling equipment such as pay loaders, mini automated loaders, high level cranes and forklift trucks. The utilisation of material handling equipment was minimal and thus, inefficient.

- **Storage of Equipment in the Warehouses**
  Most of the manufacturing companies used floor/block storage methods in their warehouses. Therefore, the use of storage equipment was minimal and inefficient.

The implication of low level of automation in order picking, material handling and storage processes is low throughput, prone to error, long order cycle time, high labour

cost and low productivity. These have negative influence by increasing logistics cost thereby increasing material cost and consequently the construction cost.

The evaluation of construction materials manufacturers warehouse efficiency was achieved by analysing data on some selected warehouse processes as presented in Sections 5.3.3.1-5.3.3.7 on pages 176-183. The results of these analyses in figures 5.86 -5.93 confirmed that construction material manufacturers warehouses process efficiency was low. Therefore, it can be concluded that research (Sub-question 3) was achieved.

The findings in Research Objective 3 above answered Research Sub-question 3: How efficient are Nigerian construction material manufacturers warehouse processes?

Research Objective 4: To evaluate the efficiency of transportation being used for the delivery of construction material from the manufacturer plants to distribution warehouses, retailer stores and construction sites.

- **Mode of Transportation**
  Road was the only mode of transport used by the manufacturing companies for delivery of material to customers.

- **Vehicle Ownership**
  Most of the companies outsourced the delivery of their material to the third-party transport service providers. But there was no synergy between the manufacturing companies and transport service providers.

- **Vehicle Capacity**
  Most vehicles used for long distance deliveries were of 30-ton capacity, and a few others were 40, 45 and 50-ton capacity. There was load consolidation in long distance delivery.

  Most vehicles used for short distance deliveries (block and sand) were of 10 tons capacity and a few others were 5, 15, 20 and 25-ton capacity.

- **Loading State of Vehicles on Arrival and Departure**

  Almost all the vehicles departed from the manufacturer plants with a full truck load. All vehicles arrived empty at the manufacturer plants. This established that empty runs for material delivery typically occurred on the forward journey to the plant. Thus, the loading state of vehicle on arrival and departure was sub-optimal and inefficient.

- **Loading and Offloading Equipment**

  A minimal number of the manufacturer warehouses used equipment in their loading processes. The majority of the DC/WHs, Retailer Stores and Sites offloaded material manually. Hence, loading and offloading processes were inefficient.

- **Number of Vehicles Loading at a Time**

  It can be concluded that time was lost because of vehicles waiting at the terminals before dispatching to their next location was unrelated to vehicle congestion experienced at the loading bay. But, this may be as a result of other adminstrative issues or inefficiencies in the system.

- **Loading and Offloading Periods**

  The restrictions and the inflexibility of loading and offloading periods to only daily working hours led to longer dwell time (fourteen hours per day) in each terminal, or both. This has affected the need for maximising of immediate, and continuous, utilisation of vehicles.

- **Loading and Offloading Time and Cost**

  The time taken to load per ton and cost to load per ton, was much lesser at the manufacturing plants, where most of these activities were done mechanically. This was in comparison to the offloading time per ton and offloading cost per ton at the distribution centres, warehouses, retailer stores and sites were mostly were done manually. Therefore, it was concluded that the loading and offloading time and cost were sub-optimal, hence inefficient.

- **Vehicle Loading Efficiency**

  Most of the vehicles had high average Shipping Efficiency (VSE), and they were more likely to be used for dispatch. But it can be concluded that the Vehicle Loading Efficiency (VLE) was very low and inefficient for the construction material deliveries. This may be explained by the frequency of empty runs occurring during the forward journeys. Thus, it needed to be improved through logistics integration.

- **Vehicle Technology**

  It can be concluded that the transport management system was not integrated with the warehouse management system, and to other systems. This could lead to ineffective and inefficient management of the transportation fleet used in the distribution network.

The study evaluated some selected transportation variables to determine the transportation system efficiency utilised by the Nigerian construction materials manufacturers. Data were collected and analysed for the transportation variables as discussed in Sections 5.3.4.1-5.3.4.12 on pages 183-196. The results of the data analyses are as presented in Figures 5.94-5.104 and table 5.4. These results provide enough evidence that the Nigerian construction materials manufacturers transportation system efficiency was low. It can, therefore, be concluded that the research (Sub-question 4) was achieved

The findings in Research Objective 4 above answered Research Sub-question 4: How efficient are Nigerian construction materials manufacturers transport systems?

Objective 5: To determine the level of technology being used in logistics processes by the Nigerian construction material manufacturers.

- **Use of Technology**

All the construction material manufacturing companies did not adopt AutoID tools in the identification and recording of data in warehouses. There was very low adoption of information technology and e-business software in logistics operations.

Therefore, the logistics process of identification and recording of data was done manually. The communication process was paper based which lead to increase in process time, high human error, duplication of effort and could reduce a logistics system's efficiency through speed, precision and reliability.

The implication of inefficiency is high cost of logistics operations which in turn lead to high cost of construction material and possibly cause delay in delivery.

The fifth research Sub-question focused on determining the level of technology adopted in logistics processes utilised by Nigerian construction material manufacturers. This was evaluated by analysing data collected on the various types of technologies adopted in logistics processes. The results of these analyses are presented in Figures 5.105-5.108 on pages 197-199. These provide enough evidence that there was low level of adoption of technology in logistics processes by the Nigerian construction materials manufacturers. Therefore, this answered research (Sub-question 5).

The findings in Research Objective 5 above answered Research Sub-question 5: What is the level of utility of technology by Nigerian construction materials manufacturers?

Research Objective 6: To evaluate the level of customer satisfaction for the delivery of construction material from the manufacturer plants to distribution warehouses, retailer stores and construction site.

- **Perfect Order Completion Index**
  The study established that on time delivery of material, damage free material deliveries and perfect order completion index were all sub-optimal. The study concluded that material deliveries by the manufacturing companies were ineffective. Therefore, the customers were not satisfied.

- **Order Cycle Time**
  The majority of the company's internal order cycle time and total order cycle time fell within the major opportunity for improvement in the customer quintile benchmark metrics. Thus, order cycle time for processing construction material

by the manufacturing companies was sub-optimal and ineffective. The study concluded that the customers were dissatisfied in terms of time taken for processing and delivery of construction material.

The sixth research Sub-question was to evaluate customer satisfaction in terms of material delivery. This was achieved by assessing the efficiency of construction material manufacturers warehouse processes from a customer satisfaction perspective. The variables evaluated include, perfect order completion indicators and total order cycle time. The results of data analyses of these variables in tables 5.7-5.10 on pages 202-205 confirmed that the level of customer satisfaction for construction material delivery was low. This invariably answered the research (Sub-question 6)

The findings in Research Objective 6 above answered Research Sub-question 6: What is the level of customers satisfaction with construction material logistics delivery?

Research Objective 7: To develop a framework for effective and efficient construction material logistics management.

The literature and empirical findings from the study provided the parameters for developing a framework for effective and efficient construction material logistics management. The framework aims at identifying and improving the effectiveness and efficiency of processing in the manufacturers warehouse and within the outbound logistics channels. The framework is presented in Figure 6.1 in Appendix B and the factors fully discussed in sections 6.8.1 to 6.8.4.on pages 228-233 Therefore, the research (Sub-question 7) was achieved.

The findings and a framework in Research Objective 7 above answered the final Research Sub-question 7: What framework can be developed to improve efficiency and effectiveness of Nigerian construction materials manufacture logistics?

The Research Problem, the Main Research Question and Sub-Questions formulated in Sections 1.3, 1.3.1, 1.4 and 1.4.1 were resolved (answered) by the findings that originated from the analysed data for research Sub-Question-Q1, Sub-Question-Q2, Sub-Question-Q3, Sub-Question-Q4, Sub-Question-Q5, Sub-Question-Q6 and Sub-Question-Q7.

7.3 Conclusions Drawn from the Research Study

The aim of the research study was to establish an understanding of the operational performance of construction material logistics management as practised by the Nigerian construction materials manufacturers, and to thereafter identify potential areas for improvement. Therefore, the research focused on the effectiveness and efficiency of the logistics system.

Based on the empirical findings, it can be concluded that the management of construction material logistics of Nigerian construction materials manufacturers or Management-CMLS, did not operate as a system. There was no collaboration and integration of the logistics systems to create a synergistic interrelationship between functions in pursuit of higher overall achievement. In addition, the goal to balance performance between the functional areas within the company, and across the supply chain was completely lacking. This was despite the promised benefits of the overall goal of the system, to create a whole or integrated effort, one which was greater than the individual sub-systems. Therefore, the study recommends the utilisation of IT towards the external integration of computerised systems of different firms and more efficient communication between the parties involved in the logistics system. Technologies such as WMS, EDI, RFID and barcode, can change the inventory strategy by improving communication between retail branches, central warehouses and manufacturers

Most importantly, the empirical findings also established that there was little adoption of automation and technology in the logistics operations. Information technology acts as the life blood of a logistics system, and acts as the glue in logistics roles, holding the network together and managing all the components of logistics. This revealed that the system partners, that is, the manufacturer warehouses, transporters, distributors, wholesalers, retailers and builders all operated in a fragmented and uncoordinated

way. Advancement in technology has been known to improve supply chain competitiveness and performance by improving the total effectiveness and efficiency of a logistics system. However, this paradigm shift has not been adopted in the Management-CMLS yet.

This study showed that manufacturer warehouses are inefficient. The biggest reason for this inefficiency is a consequence of low utilisation of automation and no adoption of information technology in warehouse processes.

Inefficient warehouse operations were identified in the following processes: packaging for transport, order picking, material handling and storage. The identification and recording of data were done manually, and communication was paper based. These practices led to low productivity and inefficiency.

The efficiency of transport operations was examined through the delivery of construction material. The field study in terms of transport operations confirmed significant inefficiencies. The main processes that illustrated low logistics efficiency for construction material were identified as the vehicle dwell time, loading and off-loading. The truck delivery processes revealed more inefficiencies in the loading state of vehicles: they were empty on arrival, confirming that empty runs for material delivery typically occurred more on the forward journey. Most of the loading and offloading of vehicles at the warehouses, retailer stores and sites were inefficient due to multiple handling of material, resulting in excessive loading and offloading time and cost.

It can also be concluded that there was inefficiency in vehicle dwell time at the terminals, leading to high time loss and underutilisation of vehicles. The vehicle loading process was inefficient. The study also found that the transport system was not integrated with the warehouse system and the other logistics partners in the supply chain. Thus, the need for optimising material outbound logistics operations, using appropriate logistics strategies and further shipment consolidation, became more and more clear. The study recommends that transporters must offer intelligent systems in their vehicles and systems.

Lastly, the crucial aspect of this research was to address the effectiveness of the logistics system, the criterion that reveals customer satisfaction. It can be concluded that the delivery of materials to customers was not effective based on delivery time, damage free delivery, internal order cycle time and total order cycle time. Customers were dissatisfied with the time taken to process and deliver construction material by the manufacturing companies. It was also established that a wide gap existed for the four customer-based metrics. The gaps represented important opportunities for improvement in bottom line results. The bottom-line results would not be attainable without refocusing warehouse administration back to the basics of efficient cost, quality and operational performance.

7.4 Contribution to Knowledge

This research study has contributed to the body of knowledge in the area of construction material logistics management. There was limited knowledge available on the subject, specifically of the logistics systems in Nigeria. This is especially so in the firms that manufacture construction material. In this regard, the following contributions are presented:

i. The research study has provided a detailed understanding of manufacturer warehousing efficiency in order processing which included order picking, material handling, storage, identification and recording of data, and means of communication with customers. The specific problem areas in material logistics have been identified using a robust methodology making it possible to have specific solutions to addressing the challenges as opposed to trial and error approaches. The details are given/provided in Figures 5.90-5.93 pages 180-183 and Figures 5.105-5.108 pages 197-199.

ii. The research study has generated a detailed understanding of transport process efficiency which included vehicle capacity, vehicle loading efficiency, vehicle utilisation efficiency , loading and offloading methods, vehicle dwell time, vehicle technology and transit time from the manufacturer warehouse to the distribution centres, warehouses, retailer stores and construction sites. The specific problem areas in the transport process have been identified using a robust methodology making it possible to have specific solutions to addressing

the challenges as opposed to trial and error approaches. The details are on Figures 5.94-5.104 pages 184-196.

iii. The research study has developed a bespoke methodology for evaluating the effectiveness and efficiency of Management-CMLS that is, management of construction material logistics as practised by construction material manufacturers in Nigeria. This is detailed in Figure 6.1 and discussed in Sections 6.8.1-6.8.4 pages 241-246.

7.5 Critical Evaluation of Methodology

The philosophy underpinning this research study was the quantitative approach. The non-participant, structured, direct observation and measurement method was used to record construction material manufacturer warehouse operations. This was based on the current order fulfilment time at existing facilities, and the transportation delivery time based on competencies of the current transportation methods.

The internal validity of the study was based on a specific setting being investigated. This included measurement of internal order cycle time, level of information technology and automation adopted in the processing of information flow and material handling at the warehouses. The dynamics of material delivery validity included the measurement of distance travelled, transit time, vehicle capacity, loading state of vehicle on arrival and at departure, vehicle waiting time at the terminal, method of loading and offloading, loading and offloading time, and the cost of transport.

Furthermore, the credibility of observations was improved by the researcher communicating directly with personnel involved in Management-CMLS. The researcher found out from the supervisors and operators what they thought about the operations and obtained details about the operational process. This triangulation helped the researcher to ascertain that the observations were not wrongly interpreted. The researcher used a camera to take photographs of operations and to video record where possible. This was done to prevent inaccurate notes and to support note taking in field situations. The findings of the research study might be applicable to other types of construction material manufacturers and their logistics management. Purposive

sampling was a reasonable choice as it aligned with the philosophical underpinning of the study.

Claims of a lack of generalisation of the research findings may be addressed through the keeping of a balanced size of the selected sites, in comparison to the average level of construction material manufacturing companies in North-Central Nigeria. The researcher believes that the results of the study can be generalisable; nevertheless, the dimension of sureness ought to be reduced outside the clear parameters used in this study. Usually, this implies that the study can only claim generalisability of the findings within the limit of the six selected construction material manufacturers. These included cement, reinforcement bars, ceramic tiles, crushed stones, hollow sandcrete blocks and sand. Be that as it may, the fundamental exploratory nature of the research does form an indicative measure of the dynamics of the Management-CMLS. Thus, the findings should be valid for all large-scale construction material manufacturers logistics systems. Furthermore, the field study took place in an environment (standard manufacturer warehouse processes and transportation operations) not designed by the researcher and had the advantage of a natural real-world view.

7.6 Limitations of the Research Study

The researcher obtained management approval for adequate access to observe logistics processes and operations. However, the researcher was denied access to some areas of operations and records of transactions, despite the assurance of anonymity and confidentiality. Managers explained that these actions were taken to safeguard the technology and business strategies from their competitors. In addition, the workers might not like the fact that they were being watched while working and could have assumed that the researcher was a management spy. In such circumstances, the validity of the data may be compromised, as the workers would not behave 'naturally'. The classic example of this was a series of studies at the Hawthorne Factory in the United States. After the study was analysed, it was found that the workers speeded up whenever they were observed, regardless of any other efforts to improve efficiency. This effect (the unintentional impact of observers on a setting), is now known as the 'Hawthorne Effect' (Fox, 1998:9).

The limitations of this study include the nature of the topic, which focuses on operational performance without considering the strategic and tactical performance. Another limitation was that the researcher allowed a limited number of assistants to help him with the tracking of drivers and the recording of their time of arrival at the various destinations. This was done with the approval of the drivers, warehouse managers, retailers and site managers.

7.7 Recommendations

Based on the findings and conclusions of this study, the following recommendations were made to enable the effective and efficient Management-CMLS - specifically in the Nigerian construction material manufacturing firms.

7.7.1 Recommendations for the Construction Material Manufacturing firms

i. Construction material manufacturing firms should create a more robust policy and system for collaboration and integration with other logistics partners. They should operate as a holistic system rather than individual entities. This will enable them to achieve better productivity and reduce cost and time of service delivery.

ii. Construction material manufacturing firms should extend the loading period to beyond 08h00-18h00 to include night hours. This would reduce vehicle dwell time.

iii. Construction material manufacturing firms should adopt automation and information technology in their logistics processes to increase productivity and connect them to other partners. The study therefore, recommends the use of technology such as WMS, EDI and RFID which will enable the material manufacturing firms to streamline receiving , put-away and picking; speed check-in, loading and check-out operations with automated documentation; reduce drive time and track shipments en-route respectively.

7.7.2 Recommendations for the Distributors, Wholesalers, Retailers, Builders and Contractors

i. These units should collaborate and integrate with other logistics partners.

ii. These units should provide loading and offloading equipment at all terminals.

iii. These units should adopt information technology to connect them with other logistics partners, especially in information sharing.

iv. These units should extend their offloading period beyond 08h00-18h00 to include night hours at the building material markets and construction sites. This would reduce vehicle dwell time.

7.7.3 Recommendations for the Transport Providers

i. Transport providers should collaborate and integrate with other transport service providers, manufacturers, distributors, wholesalers, retailers, builders and contractors.

ii. Transport providers must offer intelligent systems in their vehicles and systems.

iii. Transport providers should offer an intelligent transportation system which incorporates information technology communication (wireless) and geographical information system (GIS) software into their roads, trucks, traffic and transport systems. This would assist in tracking and monitoring vehicles in transit and guarantee more up-to-date information to transport managers and customers. This technology would ensure a prompt response service.

iv. Transport providers should address the movement of empty vehicles by working closely with partners of other transport providers in similar or dissimilar companies. They should arrange for load-matching management of material through online data exchange agreements. This is to reduce empty running of vehicles. Furthermore, seminars, training or workshops to show benefits of reducing vehicles empty runs could be conducted in conjunction with manufacturers.

v. Transport providers should ensure that some vehicles have loading, and offloading equipment installed, especially for delivery of blocks.

vi. Transport providers should use standard pallets for transporting material such as cement, ceramic tiles and blocks to maximise space and create unit loads to reduce multiple handling.

7.7.4 Recommendations for the Nigerian Government

i The Nigerian government should develop the existing infrastructure further to include durable highways and railway transport. This would enable the raw

material and finished products to be transported efficiently to the manufacturers. This would also ensure the effective delivery of material to distributors, wholesalers, retailers and end-users.

ii The Nigerian government should ensure that construction materials should have standard warehouses built in separate areas from the retailer stores for ease of traffic and conducive operations.

iii The Nigerian government should adjust its restrictive policy of closing markets at 18h00, especially for warehouses. This would allow for the offloading of material during the night and reduce vehicle dwell time.

7.7.5 Recommendations for Construction Industry Professionals

i. Construction Industry Professionals should use their knowledge and understanding of Management-CMLS channels at the start of a project to enable effective planning and delivery of the whole project through greater supply chain collaboration.

7.7.6 Implementation of the Recommendations

The recommendations on sections 7.7.1- 7.7.5 can be implemented as follows:

i. The government should provide the manufacturers and transport providers with loan facilities, tax incentives for the purchase of equipment and machines.

ii. The government should provide necessary legislation and security to extend operation time of the building material firms to include late night hours for loading and offloading at the warehouses, distribution centres and retailers.

iii. The government should enact a law to enable manufacturers, transporters, construction material merchants and construction professionals work together as a system.

iv. The government should collaborate with the private sector through public private partnerships for constructing and maintaining the roads.

v. A regulatory body should be formed to ensure implementation and operation of these laws.

7.8 Recommendations for Further Research

i. A comparative study of Management-CMLS in different geopolitical zones should be conducted to establish whether there are differences and variability in the processes employed.
ii. A study should be conducted to investigate whether the research findings do apply to other types of construction material manufacturing industries.
iii. A further study on Management-CMLS would provide more insight into the operations conducted at the strategic and tactical level of the companies, with special focus on barriers to collaboration; integration of systems, adoption of automation and the use of technology in logistics processes

7.9 Cautionary Guidelines

The recommendations in this study should be adopted with caution as the findings are based on selected construction material manufacturers in North-Central Nigeria, and the conclusions are based on the chosen methodology.

7.10 Chapter Summary

The researcher acknowledges that the construction industry is one of the fastest growing sectors in Nigeria. It is hoped that this study would contribute to the further development of the industry, and through it, to the economic and social upliftment of the Nigerian people.

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9.0 Appendix A : Survey Instrument

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01st December 2016

Dear Respondent,

PhD Research Thesis: Mr ALUMBUGU, Polycarp Olaku

I wish to confirm that the bearer of this letter Mr. ALUMBUGU, Polycarp Olaku is a bonafide PhD candidate in the Department of Construction Management within the school of the Built Environment at the Nelson Mandela Metropolitan University in Port Elizabeth, South Africa. His thesis project is titled: "***Construction Material Logistics Management: The case of North Central Nigeria".***

Mr ALUMBUGU is now conducting field studies and requires input from the Nigerian construction and manufacturing industries, distributors/retailers and associated organisations. The purpose of this letter is to request you to provide Mr. ALUMBUGU, Polycarp Olaku with any possible assistance by providing information for his research work.

Thank you for the opportunity to introduce Mr ALUMBUGU. Should you require any further information, please do not hesitate to contract me on the detailed provided below.

Yours Sincerely,

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Construction Material Logistics Management: The Case of North Central Nigeria.

SECTION ONE: MANUFACTURING INDUSTRY

Date:

Name of Company:.....

Designation of the officer:.....

Email address:.....

Contact No: .....

Time of arrival to site:.....

1.0 Day of the week

Monday	**1**	Tuesday	**2**	Wednesday	**3**	Thursday	**4**	Friday	**5**	Saturday	**6**	Sunday	**7**

2.0 Types of Material Produced

2.1 Identification of the type of Material Produced by Company

Cement	**1**	Steel reinforcement bar	**2**	Paints	**3**	Ceramic tiles	**4**	Burnt bricks	**5**
		Stone aggregate	**6**	Sand	**7**	Sandcrete blocks	**8**		

2.2 Identification of cost of product at the company …….....

3.0 Identification of Logistical Channels utilised by the Company

3.1Identification of Logistics Channels

Direct - to- End user	**1**	Retailer- End user	**2**	DC/WH- Retailer- End- user	**3**	Agent/Marketer- Distributor/wholesaler-Retailer -End user	**4**	Builders Merchant/ Material Supplier	**5**

3.2 Locations and Numbers of Distribution Centres, Warehouses and Retailers Stores

Location	FCT Abuja	**1**	Kogi Lokoja	**2**	Niger Minna	**3**	Nasarawa Lafia	**4**	Plateau Jos	**5**	Benue Makurdi	**6**
No of DC/WH	`											

4.0 Identification of Logistics Sub-systems, Collaboration and Integration Indicators

4.1 Identification of Logistics System Collaboration and Integration Indicators

Collaboration	**Yes**	**No**
Informal processes relying on mutual respect, information sharing, and joint ownership of decisions and rewards		
Sharing of forecasting information		
Working across boundaries to build value-adding offerings		
Collaboration has been characterised to occur between the functions within firms, as well as across boundaries between firms in a supply chain		
Trust and commitment		
Coordination refers to a more direct, active cooperation- indicates an interactive, joint decision-making process		
Integration		
Seamlessly linking processes between firms		
Collaborating at both the strategic and operational levels		
Interconnecting business processes both within and between firms		
Incorporating suppliers and their customers into cohesive networks		
Having both internal and external forms		
The external components of integration have been segmented into unique dimensions based on whether the integration is with customers or suppliers		
Operational integration, managerial integration and geographical integration		
The individual systems sacrifice some degree of autonomy to achieve the overall purpose		

4.2 Identification of Logistics Sub-systems utilised by Construction Material Manufacturing Companies.

Warehouse	1	Transport	**2**	Packaging	**3**	Material Handling	**4**
Inventory	**5**	Order Processing	**6**	Information Technology	**7**		

5.0 Consumption and Demand by Distributors/Warehouses, Retailers Stores and Sites

5.1 Consumption /Demand by Distributors /Warehouses, Retailer Stores and Sites

	FCT Abuja	**1**	Lokoja	**2**	Minna	**3**	Lafia	**4**	Jos	**5**	Makurdi	**6**
Average quantities per week												
Average quantities per month												

5.2 Actual quantities Supplied to Distributors /Warehouses, Retailer Stores and Sites

	FCT Abuja	**1**	Lokoja	**2**	Minna	**3**	Lafia	**4**	Jos	**5**	Makurdi	**6**
Average quantities per week												
Average quantities per month												

6.0 Network Structure, Size and Space utilisation of Manufacturer Warehouses

6.1 Network Structure of Manufacturer Warehouses

Consolidation	**1**	Break-bulk	**2**	Mixed	**3**	Cross-docking	**4**

6.2 Identification of Size of Manufacturer Warehouses (m^2)

Less than 500m²	**1**	501-3000 m²	**2**	3001-5000 m²	**3**	5001-7500 m²	**4**
7501-10,000 m²	**5**	Above10,000 m²	**6**				

6.3 Warehouse Space Utilisation

Type of Space	**Full (90)**	**3/4 (75)**	**1/2 Full (50%)**	**1/4Full (25%)**
Floor space utilisation **1**				
Cube-Method utilised **2**				
Building utilisation **3**				
Pallet location utilised against total no of location available **4**				

6.4 Average number of Store Keeping Unit (SKU)

Units	Tonnage	**1**	Volume	**2**	Drums	**3**
Quantity						

6.5 Inventory Types

Large inventory	**1**	Buffer inventory	**2**	Zero inventory	**3**

6.6 Method of Storage in the Warehouse

Floor block storage	**1**	Single deep racking	**2**	Double deep racking	**3**	Push back racking	**4**	Drive in through racking	**5**
Pallet floor racking	**6**	Powered mobile racking	**7**	Narrow aisle racking	**8**	Single deep AS/RS	**10**	Double deep AS/RS	None

6.7 Identification of the Packaging System

Standard Pallets	**1**	Container	**2**	Packets	**3**	Tins	**4**	Drums	**5**
Bulk	**6**	Bags	**7**	Carton	**8**	Bundles	**9**		

7.0 Mode of products Transportation by Manufacturers

7.1 Identification of Mode of Transportation used by the Manufacturing Industry

Rail	**1**	Road	**2**	Air	**3**	Water	**4**	Railroad	**5**	Others specify	**6**

8. 0 Manufacturer's Loading Area

8.1 Identification of size of Loading/Offloading area

Size	Length x Breadth	No of trucks loading at a time. **8.1.1**	1-3	**1**	4-6	**2**	7-10	**3**	11-15	**4**	Above 15	**5**
Area 8.1.2			**6**									

8.2 Identification of Loading Period

6.00-8.01Hrs	**1**	8.01-18.01 Hrs.	**2**	18.01-22.00 Hrs.	**3**	24.00 Hrs.	**4**

8.3 Loading Method and Equipment

Self-loading	**1**	Hand loaded	**2**	Forklift truck	**3**	High level Crane	**4**	Payloader	**5**	AGV (Automatic loading machine	**6**	Pump/jack loaded	**7**

9.0 Identification of Technology and Automation adoption in Logistics

9.1 Technology Adoption

9.1.1 Automatic identification and data capturing tools

Barcode scanner	**1**	RFID	**2**	Voice recognition	**3**	Pick by light	**4**	Put to light	**5**	None	**6**

9.1.2 Identification of Communication Technology tools

EDI	**1**	VSAT	**2**	GPS	**3**	GIS	**4**	Web-based Tracking	**5**	AGVS	**6**	IDS	**7**	None	**8**

9.1 3 Identification of information Technology tools

ERP	**1**	MRP	**2**	DRP	**3**	AITS	**4**	WMS	**5**	RFID	**6**	No Automation	**7**

9.1.4 Identification of E-business application

Internet access	**1**	E-mail	**2**	Website	**3**	Intranet	**4**	Selling &Buying online	**5**	None
Extranet	**6**	E-banking	**7**	E-market place	**8**	E-SCM, E-CRM	**9**	Collaborative platform	**10**	

9.2 Automation Adoption

9.2 1 Identification of order picking method

Paper picking	**1**	Pick by label	**2**	Barcode scanning	**3**	Voice picking	**4**	Pick to light	**5**	Put to light	**6**	RFID	8	WMS	**9**	Automated picking	**10**

9.2. 2 Handling Equipment in Warehouses

Fork lift truck	**1**	Powered pallet Truck/Low level	**2**	Counterbalance fork lift	**3**	High level order picking truck	**4**	High level order picking crane	**5**
layer picker	**6**	Bin shelving	**7**	Storage drawers	**8**	Flow rack (cartons or totes)	**9**	Horizontal carousels	**10**
Vertical carousels	**11**	Mini load AS/RS	**12**	Belt Conveyors	**13**	Mini Automated Loader	**14**	Pick-to-tote (or cartons)	**15**
Sortation Conveyor	**16**	None	**17**						

9.2.3 Identification of materials transportation equipment (Conveyors)

Chute-conveyor	**1**	Belt Conveyor	**2**	Roller conveyor	**3**	Wheel conveyor	**4**
Slat conveyor	**5**	Chain conveyor	**6**	Tow line conveyor	**7**	Trolley-conveyor	**8**

10.0 Human Resources and Skills in the Manufacturing Industry Warehouse

10.1 Identification of number of employees

Labour	Admin staff	**1**	Skilled	**2**	Unskilled	**3**
No of staff in the warehouse						
No of working hours per day						

10.2 Identification of training for Employees

In house training	**1**	External training	**2**	None	**3**

10.3 Identification of incentive/ motivation given to Employees

Financial	**1**	Non-financial	**2**	Others (specify)	**3**	None	**4**

11.0 Order cycle time (**Productivity in the Manufacturers Warehouse)**

11.1 Internal Order Cycle Time (Order receiving and processing including loading of Vehicle ready for shipment)

11.1.1	Date of Order received	
11.1.2	Start time of Internal Order processing	
11.1.3	Quantity of Material ordered	
11.1.4	Date Internal order processing completed	
11.1.5	Time Internal Order Cycle is completed.	
111..6	Total Internal Order Cycle Time (Hrs.)	

12. 0 Post-transaction services

12.1 Identification of post transaction services

Installation	**1**	Warranty	**2**	Alteration	**3**	Repairs	**4**	Replacement of damaged materials	**5**	None	**6**

12.2 Identification of failure in manufacturer's warehouse/store

	Failure in Warehouse	Qty	**%**	**Yes**	**No**
12.2.1	Shortage in quantity delivered				
12.2.2	Excess in quantity delivered				
12.2.3	Article mixed up (wrong product)				
12.2.4	Damages returned				
12.2.5	An order filling error by seller				

13.0 Summary of Daily Performance

13.1Total number of orders received per day…….

13.2 Total number of orders processed per day…….

13.3 Total cost of labour per day…….

SECTION TWO: TRANSPORTATION (Fleet Efficiency and Vehicle Efficiency)

Date:

Name of Company: …….

Designation of the officer……

Email address: …….

Contact No: ……

Time of arrival to site: …….

14.0 Day of the week

Monday	**1**	Tuesday	**2**	Wednesday	**3**	Thursday	**4**	Friday	**5**	Saturday	**6**	Sunday	**7**

15.0 Vehicle information

15.1 Identification of Vehicle Manufacturer

Howo	**1**	Daf	**2**	Mark	**3**	Iveco	**4**	Benz Actross	**5**	Man Diesel	**6**
911 Lorry	**7**	Ginoff	**8**	Pick-up van	**9**	Mistubushi	**10**	Others specify			

15.2 Identification of Type of vehicle

Open	**1**	Closed	**2**	Tipper	**3**	Skip	**4**	Ready mix	**5**	Dumper	**6**

15.3 Identification of Age of Vehicle (years)

0-5	**1**	6-10	**2**	11-15	**3**	15-20	**4**	Above 20	**5**

15.4 Identification of Vehicle ownership

Manufacturer	**1**	Wholesaler/Retailer	**2**	Third party	**3**	Others specify	**4**

15.5 Identification of Condition of Vehicle used for delivery

New	**1**	Well maintained	**2**	Average	**3**	Poor	**4**

16.0 Vehicle consumables/ maintenance

16.1 Identification of Quantity of Consumables used and price/liter

Type	Diesel	**1**	Petrol	**2**	Others specify	**3**
Quantity in litre						
Price/litre						

16.2 Identification of frequency of maintenance of vehicle

Complete servicing of vehicle	Per trip	**1**	weekly	**2**	monthly	**3**	Bi-monthly	**4**
Total cost per maintenance								

17.0 Vehicles Capacity and Utilisation

17.1 Identification of Vehicle capacity

Tons	5	**1**	10	**2**	15	**3**	20	**4**	25	**5**	30	**6**	40	7	Above 45	**8**

17.2 Identification of State of Vehicle on arrival by volume

Full	**1**	¾ Full	**2**	½ Full	**3**	¼ Full	**4**	Empty	**5**

17.3 Actual Tonnage:.....

17.4 Actual Capacity:.....

17.5 State of vehicle on departure by volume

Full	**1**	¾ Full	**2**	½ Full	**3**	¼ Full	**4**	Empty	**5**

18.0 Type of Material

18.1 Identification of Material Being Transported

Cement Only	**1**	Steel reinforcement bar only	**2**	Paints only	**3**	Ceramic tiles	**4**	Burnt bricks	**5**
Sand	**6**	Stone aggregate	**7**	Sandcrete block	**8**	Mixed materials	**9**		

19.0 Loading and Offloading, Time and Cost

19.1 Method of Loading/ Offloading

Loading	Self-loading	**1**	Hand loading	**2**	Forklift Truck	**3**	High level Crane	**4**	Pay loader	**5**	Automatic Loader	**6**	Pump Jack loader	**7**
Offloading	Self-offloading	**1**	Hand offloading	**2**	Forklift Truck	**3**	High level Crane	**4**	Pay loader	**5**	Automatic Loader	**6**	Pump Jack loader	**7**

19.2 Identification of Number of Vehicles Loading at a Time at Manufacturer Warehouse

1-3	**1**	4-6	**2**	7-10	**3**	11-15	**4**	Above 15	**5**

19.3 Identification of Number of Vehicles offloading at a Time at DC /Warehouse and Retailer Store

1-3	**1**	4-6	**2**	7-10	**3**	11-15	**4**	Above 15	**5**

19.4 Identification of Vehicle Waiting Time at the Manufacturers at Warehouse before loading

0-3Hrs	**1**	3.01-6.0Hrs	**2**	6.01-9.00Hrs	**3**	9.01-12.00Hrs	**4**	12.01-15.00Hrs	**5**	Above 15.01Hrs	**6**

19.5 Identification of Vehicle Waiting Time at the DC/Warehouse, Retailer Store and site before off loading

0-3Hrs	**1**	3.01-6.0Hrs	**2**	6.01-9.00Hrs	**3**	9.01-12.00Hrs	**4**	12.01-15.00Hrs	**5**	Above 15.01Hrs	**6**

19.6 Quantity loaded/ offloaded, Time taken and cost of labour

		Loading	Off loading
19.6.1	Actual time taken (Minutes)		
19.6.2	Actual quantity (Tons)		
19.6.3	In case of hand load, No. of workers used (labour)		
19.6.4	Total cost for loading or offloading a vehicle(₦)		

20.0 Transit Time

20.1 Identification of Distance driven/ Time driven

20.1.1	Location of Manufacturer Warehouse/Plant (location of pickup delivery)	
20.1.2	Location of DC/Warehouse, Retailer Store and Site (Location of suppliers point of use)	
20.1.3	Total quantity of Material driven per Vehicle (tons)	
20.1.4	Total Distance driven per delivery (km)	
20.1.5	Actual cost of Transport per delivery (#)	
20.1.6	Date/Time of Departure from Manufacturer Warehouse/Plant	
20.1.7	Date/Time of Arrival at DC/WH, Retailer Store and Site	
20.1.8	Total Transit Time	

20.2 Identification of drivers breaks on the road

No of stoppages/ trip	1-3No	**1**	4-6	**2**	7-10	**3**	11-15	**4**	Above 15	**5**
Average time spent on each stoppage	30Min	**1**	31-59Min	**2**	1 1/2 Hrs.	**3**	2-3	**4**	Above 3Hrs	**5**

21.0 Information Technology

21.1 Identification of Vehicle Automation

Forklift	**1**	Intelligent transport integrated information technology	**2**	Wireless	**3**	GIS	**4**	Material tracker	**5**
Speed limit	**6**	Satellite navigation	**7**	others	**8**			No automation	**9**

22.0 Employees information

22.1 Identification of Transportation Workers

Operating personnel drivers (No)	1-2	**1**	3-4	**2**	5-8	**3**	Above 8	**4**
Supporting staff (maintenance)								
Supporting staff (loading/offloading)								
Managerial personnel								

22.2 Identification of driver's age group

20-30 years	**1**	31-50years	**2**	Above 50 years	**3**

22.3 Identification of driver's experience

Driving experience in years	<5	**1**	5-9	**2**	10-14	**3**	15-19	**4**	>20	**5**

22.4 Identification of mode of employment

Tenure	**1**	Part time	**2**	Contract	**3**	Others (specify)	**4**

22.5 Identification of numbers of drivers using a vehicle per a trip

1 Driver	**1**	2Drivers	**2**	3 Drivers	**3**	Above 3 Drivers	4

22.6 Identification of Training for employees

In house training	**1**	External training	**2**	None	**3**

22.7 Identification of incentive/ motivation given to Employees

Financial	**1**	Non-financial	**2**	Others (specify)	**3**	None	**4**

23.0 Summary of Daily Performance

23.1 Total number of orders received per day: …….

3.2 Total number of orders processed per day……....

23.3 Total cost of labour per day……...

SECTION THREE: DISTRIBUTION CENTRE/WAREHOUSING

Date:

Name of Company ……

Designation of the officer…….

Email address……

Contact no…….

24.0 Day of the Week

Monday	**1**	Tuesday	**2**	Wednesday	**3**	Thursday	**4**	Friday	**5**	Saturday	**6**	Sunday	**7**

25.0 Types of Materials Produced

25.1 Identification of the type of material produced by company

Cement	**1**	Steel reinforcement bar	**2**	Paints	**3**	Ceramic tiles	**4**	Burnt bricks	**5**
		Stone aggregate	**6**	Sand	**7**	Sandcrete blocks	**8**		

25.2 Identification of number of suppliers to the warehouse

Numbers of suppliers	1-2	**1**	3-5	**2**	6-10	**3**	11-15	**4**	16-30	**5**	Above 30	**6**

25.3 Identification of average numbers of customers being served by the warehouse.

Numbers of customers	1-50	**1**	51-150	**2**	151-300	**3**	301-500	**4**	Above 500	**5**

25.4 Identification of cost of product at the company …….....

26.0 Network Structure, Size and Space Utilisation of Manufacturer Warehouses

26.1 Network Structure of Manufacturer Warehouse

Consolidation	**1**	Break-bulk	**2**	Mixed	**3**	Cross-docking	**4**

26.2 Identification of Size of Manufacturers Warehouse (m^2)

Less than 500m²	**1**	501-3000 m²	**2**	3001-5000 m²	**3**	5001-7500 m²	**4**
7501-10,000 m²	**5**	Above10,000 m²	**6**				

Identification of Warehouse size/ Capacity

26.3 Actual length x Breadth……Total area……..

26.4 Attached office area…….

26.5 Warehouse Space Utilisation

Type of Space	**Full (90)**	**3/4 (75)**	**1/2 Full (50%)**	**1/4Full (25%)**
Floor space utilisation **1**				
Cube-Method utilised **2**				
Building utilisation **3**				
Pallet location utilised against total no of location available **4**				

26.6 Average number of Store Keeping Unit (SKU)

Units	Tonnage	**1**	Volume	**2**	Drums	**3**
Quantity						

26.7 Inventory Types

Large inventory	**1**	Buffer inventory	**2**	Zero inventory	**3**

27.0 Identification of Technology and Automation Adoption in Logistics

27.1 Technology Adoption

27.1.1 Automatic identification and data capturing tools

Barcode scanner	**1**	RFID	**2**	Voice recognition	**3**	Pick by light	**4**	Put to light	**5**	None	**6**

27.1.2 Identification of Communication Technology Tools

EDI	**1**	VSAT	**2**	GPS	**3**	GIS	**4**	Web-based Tracking	**5**	AGVS	**6**	IDS	**7**	None	**8**

27.1 3 Identification of Information Technology Tools

ERP	**1**	MRP	**2**	DRP	**3**	AITS	**4**	WMS	**5**	RFID	**6**	No Automation	**7**

27.1.4 Identification of E-business Application

Internet access	**1**	E-mail	**2**	Website	**3**	Intranet	**4**	Selling &Buying online	**5**	None
Extranet	**6**	E-banking	**7**	E-market place	**8**	E-SCM, E-CRM	**9**	Collaborative platform	**10**	

27.2 Automation Adoption

27.2 1 Identification of order picking method

Paper picking	**1**	Pick by label	**2**	Barcode scanning	**3**	Voice picking	**4**	Pick to light	**5**	Put to light	**6**	RFID	7	WMS	**8**	Automated picking	**9**

27.2. 2 Handling Equipment in Warehouse

Fork lift truck	**1**	Powered pallet truck/Low level	**2**	Counterbalance fork lift	**3**	High level order picking truck	**4**	High level order picking crane	**5**
layer picker	**6**	Bin shelving	**7**	Storage drawers	**8**	Flow rack (cartons or totes)	**9**	Horizontal carousels	**10**
Vertical carousels	**11**	Mini load AS/RS	**12**	Belt Conveyors	**13**	Mini Automated Loader	**14**	Pick-to-tote (or cartons)	**15**
Sortation Conveyor	**16**	None	**17**						

27.2.3 Method of Storage/Equipment used in the DC/Warehouse and Retailer Store

Floor block storage	**1**	Single deep racking	**2**	Double deep racking	**3**	Push back racking	**4**	Drive in through racking	**5**
Pallet floor racking	**6**	Powered mobile racking	**7**	Narrow aisle racking	**8**	Single deep AS/RS	**10**	Double deep AS/RS	**11**

27.2.4 Identification of Material Transportation Equipment (Conveyors)

Chute-conveyor	**1**	Belt Conveyor	**2**	Roller conveyor	**3**	Wheel conveyor	**4**
Slat conveyor	**5**	Chain conveyor	**6**	Tow line conveyor	**7**	Trolley-conveyor	**8**

28.0 Human Resources and Skills in the DC/Warehouse and Retailer Store

28.1 Identification of number of employees

Labour	Admin staff	**1**	Skilled	**2**	Unskilled	**3**
No of staff in the warehouse						
No of working hours per day						

28.2 Identification of training for Employees

In house training	**1**	External training	**2**	None	**3**

28.3 Identification of incentive/ motivation given to Employees

Financial	**1**	Non-financial	**2**	Others specify	**3**	None	**4**

29. 0 Post-transaction services

29.1 Identification of post transaction services

Installation	**1**	Warranty	**2**	Alteration	**3**	Repairs	**4**	Replacement of damaged materials	**5**	None	**6**

29.2 Identification of Failure in Material Delivery at the DC/Warehouse and Retailer Stores

	Failure in Warehouse	Qty	**%**	**Yes**	**No**
29.2.1	Shortage in quantity delivered				
29.2.2	Excess in quantity delivered				
29.2.3	Article mixed up (wrong product)				
29.2.4	Damages returned				
29.2.5	An order filling error by seller				

29.3 Identification of Perfect Order Completion Indicators

	Indicator	**Yes**	**No**
29.3.1	On time		
29.3.2	In full delivery		
29.3.3	Damage free delivery		
29.3.4	Order fill rate complete		
29.3.5	Order accuracy		

30.0 Summary of Daily Performance

30.1Total number of orders received per day……

30.2 Total number of orders processed per day…….

30.3 Total cost of labour per day……

10.0 Appendix B: Framework

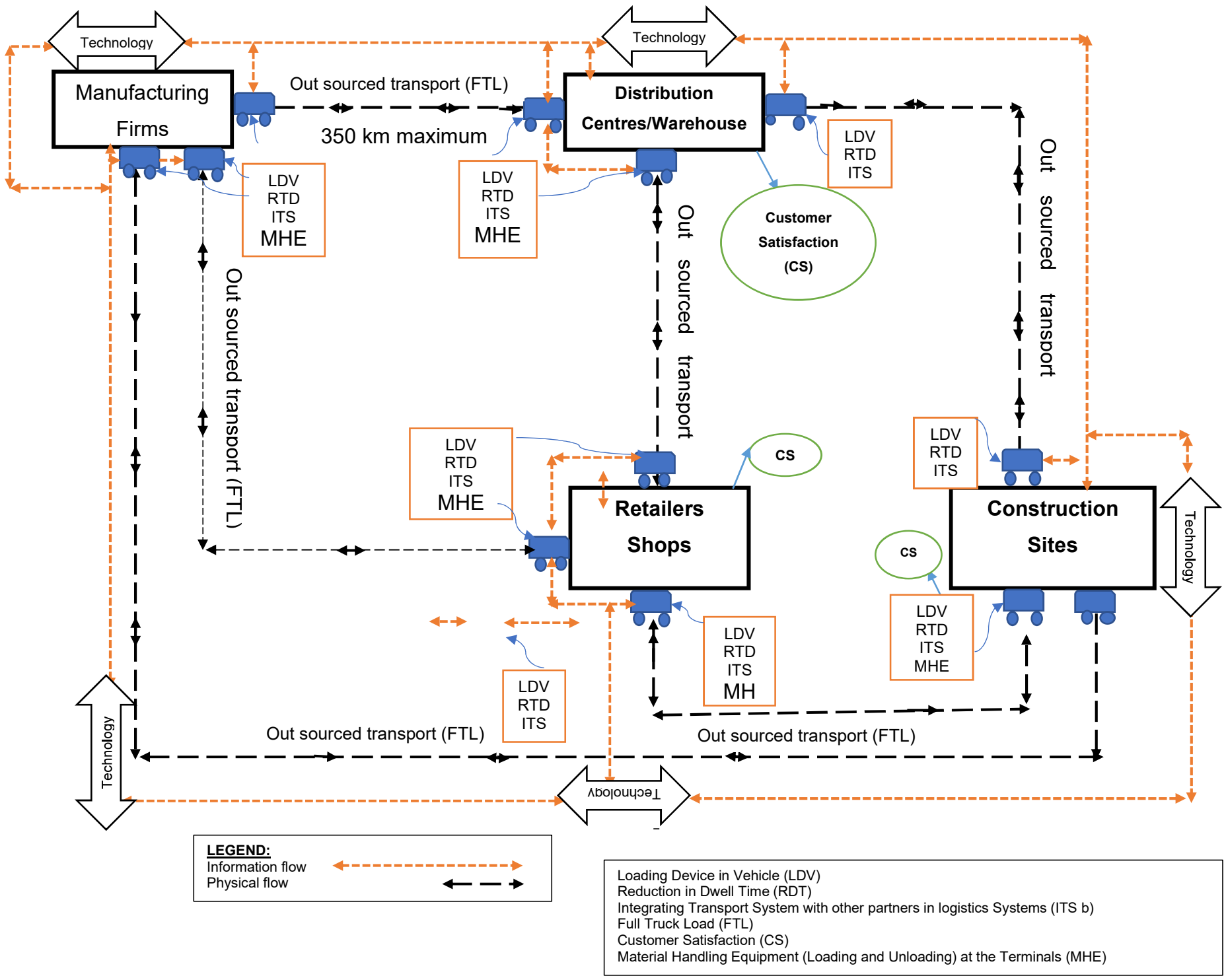

Figure 6.1: Framework for Effective and Efficient Construction Material Manufacturers Logistic Management
Source: Author's Design (2019)

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